WORLD CONCLAVE OF SCIENTISTS
ON
REGIONAL CO-OPERATION IN SCIENCE AND
TECHNOLOGY: OPPORTUNITIES AND CHALLENGES IN
THE CONTEXT OF GLOBALISATION

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MESSAGE

I am very happy to learn that Zaheer Science Foundation is bringing out the Proceedings of the recently held World Conclave of scientists on ‘Regional Co-operation in Science and Technology: Opportunities and Challenges in the context of Globalization’. The Conclave was attended by more than 100 delegates from South Asia, South East Asia, Central Asia, Europe, North and South America, who presented very useful papers of topical interest based on years of their research experience covering a wide gamut of emerging areas of science & technology. The Proceedings will help in keeping the scientists and technologists abreast of the latest trends in the concerned areas. In fact, publication of the Proceedings and their circulation will go a long way in fulfilling the mandate of Zaheer Science Foundation for the promotion of science, technology and higher education and also serve the very purpose of the Conclave, namely meeting the challenges and utilizing the opportunities which have emerged from the globalization of the world economy. It will also promote greater understanding and interaction between the scientists, educationists and parliamentarians of the region covering South Asia and South East Asian Countries.

I take this opportunity to thank the organizers of the Conclave namely, Zaheer Science Foundation, UNESCO, ISESCO and all the Government Departments which supported the Conclave. I would also congratulate Dr. Mohsin U Khan, Coordinator of the Conclave and other officers and staff of the Foundation for preparing the Proceedings and the officers of NISCAIR & NISTADS (CSIR) for editing and printing the Proceedings.

(A.R. KIDWAI)

Chairman,
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Former Governor of Bihar, West Bengal
& Haryana and Ex-Member, Rajya Sabha

DR. A. R. KIDWAI
PREFACE

Until the 19th century scientific discoveries and inventions were person centered. Edison, Newton, Faraday, Bell, Ford were all individual innovators. Innovation became institutionalized in the 20th century and that accelerated the phase of discoveries and inventions in food, energy, time, materials, transportation, space exploration and conquest of life process. In this 21st century the mantra is alliances and partnerships, cutting across national, ideological and social barriers. CERN, Human Genome, HIV, Climate Change are examples.

Nations in South Asia and south East Asia have several common attributes and resources which can be harnessed to forge alliance and build programs to advance knowledge base and benefits to national economies. It is a duty and responsibility of the scientific communities in the region to present the relevant perspectives to their governments and nationals leaders.

I am happy that this Conclave of Scientists, supported by UNESCO, ISESCO, and Government Agencies of India, has been able to identify a range of issues of shared interests on which bankable projects can be mounted. It is indeed a novel idea to involve the policy making Parliamentarians, as their participation can provide valuable insights and directional signals for achieving success.

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INTRODUCTION, THEME AND OBJECTIVES OF THE CONCLAVE

The world scientists conclave which has been organized by UNESCO South Asia and Southeast Asia Science and Technology Policy Forum and Zaheer Science Foundation on “Regional Cooperation in Science and Technology: Opportunities and Challenges in the context of Globalization” during 26-29th November 2010 at Indian National Science Academy (INSA), New Delhi is in continuation of the two previous International Conferences held in 2005 and 2007, respectively. The first Conference was inaugurated by Shri Kapil Sibal, Hon’ble Minister of State for Science and Technology. The second Conference was inaugurated by Shri Pranab Mukherjee, the then Hon’ble Union Minister for External Affairs and presided over by H.E. Mr. Koichiro Matsurra, Director General, UNESCO.

This was a big event where a large number of foreign delegates from South Asia, Southeast Asia, Europe and North America as well as South America and Russia have participated. One of the interesting features of the Conclave was that half day on 29th November 2010 devoted to the Parliamentarian of the region. UNESCO has suggested that for this year’s Conclave we should also invite members of Parliament in South Asia and Southeast Asia region dealing with science policy. This has been a major scientific get-together which considered various aspects for cooperation and coordination among scientists of the region.

There was an opportunity to have one on one interaction among the delegates to work out research programs on regional cooperation in Science and Technology especially in the field of higher education, drugs and pharmaceuticals, health services, information technology, energy and environment and agricultural sciences. The conclave in broader sense is to encourage regional cooperation in science and technology for the advancement of South Asia and south East Asia region. Researchers, academicians, Member of Parliaments from Asia and Pacific region, people from industry and government departments have been invited to share their experiences, knowledge and research. The theme of the conference offered panelists a venue to express, recognize and define and question the many and varied interface between science and society. Various research perspectives were discussed on following topics:

- Regional cooperation in drugs and pharmaceutical industry
- Health Services in Urban and Rural Areas
- Agriculture, Biotechnology, Medicine and ethical issues
- Information technology and society
• **Issue related; hazardous chemicals; waste management, sludge and sewage management for clean and green environment**

• **Status of R&D in India and other countries: S&T Manpower; Organization and Structure of R&D; Science and Technology Policy and Technology Trade.**

India has emerged as a focal point in the field of Science and technology and higher education for this region, followed by its economic development. This has made the scientists, especially from developing countries, to attend such a Conclave in India voluntarily.

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Inaugural Session
Dr. Abid Hussain
Inaugural address by Dr. Abid Hussain  
Formerly Ambassador to USA

His Excellency Dr. B. P. Singh, Dr. Lidia Brito, Dr. G. Thyagarajan, Dr. M. U. Khan, distinguished scientists, academics and friends.

I am glad to be in your midst at this Conclave of scientists where delegates from across the globe have assembled to participate and contribute effectively to the brain-storming discussions on a very important topic namely, Regional Cooperation in Science and Technology: Opportunities and Challenges in the Context of Globalization. The Conclave is being organized by UNESCO, South Asia and South East Asia Science and Technology Policy Forum and Zaheer Science Foundation. UNESCO has chosen Zaheer Science Foundation as a nodal agency for the South Asia and South East Asia Science and Technology Policy Forum to promote regional cooperation in the region. The present Conclave is in continuation of the two previous Conferences held in 2005 & 2007, respectively.

In this context, I would like to go back in the history of the development of modern knowledge based science and technology in post independence era. At the initiative of Pandit Jawahar Lal Nehru a decision was taken in the Conference of scientists, technologists and educationists held in August, 1963 that the first Scientific Policy Resolution of 1958 should not remain nearly on paper but should form a basis for intensive discussion among the scientists and educationists of the country so as to work out plans and programs for the speedy socio economic development of the country. The Scientific Policy Resolution was further reviewed in two more Conferences of scientists, technologists and educationists in 1967 and 1970, respectively. The Conference held in 1970 which was inaugurated by the then Prime Minister Smt. Indira Gandhi emphasized that the broad objective of the Scientific Policy Resolution was to benefit the people of the country with the acquisition and application of scientific knowledge.

Against this background Zaheer Science Foundation was established in 1970 as an NGO whose mandate was to help the Government Departments in the promotion of scientific research and educational reform activities. Dr. Zaheer, in whose name the Foundation was established, felt that the types of Conferences held in 1963, 1967 & 1970 should be continued to consider various issues of development of the country and for this purpose, an independent organization in the form of an NGO might be set up which could make useful recommendations to the Government and thus help in the promotion of socio-economic development of the country on the basis of science and technology keeping in view the latest global trends in knowledge based areas.

I am happy to note that the dream of Dr. Zaheer is going to be fulfilled to a great extent. As one who has observed the activities of the Zaheer Science Foundation for the last several years, I can say without any reservation that the Foundation has functioned as per its mandate and contributed to the promotion of science and technology. The Foundation has been playing a great role in promoting regional cooperation on science and technology. It should be ensured by the Foundation that in the context of the globalization of the economy which has thrown up new opportunities for the people world over to participate in the developmental activities, it plays a greater role in building an atmosphere of cooperation specially in the area of science policy and programmes to face future challenges.
The deliberations of the present Conclave will go on for four days. I understand that more than 100 delegates are attending this Conclave and will present very useful papers with their distilled wisdom gained from years of experience of research in the emerging and cutting edge areas of science and technology. I am glad that despite your preoccupation, you have found time to come to this International Conclave. I am sure that for the next four days you would be able to have very fruitful deliberations and chart out a roadmap for bringing together scientists and intellectuals for promoting cooperation in all issues concerning development through science and technology in each of the participating countries. I am sure the deliberations at this Conclave will go a long way in meeting the challenges thrown up in the context of globalization of economy particularly among the South Asia and South East Asian countries, many of which are becoming fast growing economies. It is really heartening to note that on the last day of the Conference members of Parliament from several countries in South East Asia have been invited. I am sure the interaction between the scientists and the parliamentarians will be very effective and would very much serve the purpose of the Conclave namely to work out strategies for dealing with the problems of development in this part of the world and will show us how best we can utilize the opportunities of globalization. I would like to congratulate the organizers of this Conclave namely, Zaheer Science Foundation, UNESCO, ISESCO and all the Government Departments which are supporting the Conclave. I wish the Conclave all success.
Dr. Lidia Brito
Address by Dr. Lidia Brito,
Director,
Science Policy and Sustainable Development Division,
UNESCO, Paris

Excellencies,
Distinguished Delegates,
Ladies and Gentlemen

It gives me a great pleasure to address this opening ceremony of this Science Policy Forum which will focus on the ways in which globalization changes science and technology and vice versa and the opportunities these changes offer in the better utilization of Science and Technology to foster peace, improve the quality of life of peoples and promote the sustainable growth and development in the region. It will stress the important issue of regional cooperation on science and technology, notably the challenges and opportunities for policy-making.

Firstly, I wish to thank all partners for their hard work in organizing this Forum – namely: the Zaheer Science Foundation; the Indian National Science Academy; ISESCO, and the Department of Science and Technology within the Ministry of Science and Technology of India for its support.

I am particularly grateful to Professor A. R. Kidwai, Chairman of the Zaheer Science Foundation, for taking the initiative to convene this Forum in the continuity of the first Forum on March 2005 at Chandigarh and second in November 2007 in Delhi.

The topic of this Forum is obviously one that is of central concern to all engaged in building the future in the South and South East Asia region. It gives us the opportunity to look with fresh eyes at the dynamic interface between regional cooperation in science and technology and globalization.

Over the next four days, we will discuss regional co-operation and co-ordination in science and technology in addressing some of the most pressing issues concerning the future such as climate change and environmental challenges. We will debate a new regional research and policy agenda focused on themes such as science, technology and economic development, innovation management and transfer, the impact of science in society. We will also develop strategies to ensure the political commitment to support the implementation of such an agenda.

I don't have to tell this audience of eminent people that the globalization process to date has made significant contributions by creating a new international context for science and technology and how the relation between globalization and science has become more and more complex and dynamic. It is clear that globalization has transformed the nature and function of science. At the same time, science and technology have been forces driving globalization, as it transcends borders and cultures in the pursuit of knowledge and the free exchange of ideas. Because of increased globalization, scientific research has been characterized by global information and knowledge networks and scientific communities operating on a worldwide scale.

Globalization has been accompanied by important changes in the creation, application, diffusion and transfer of knowledge. Such changes include major increase in the speed, scale and scope of knowledge production and diffusion, growing commercialization and new types of partnership and cooperation.
It goes without saying that one of the key elements of sustainable development in the current global scenario is the mastery of science and technology (S&T). It is often said the “knowledge is power”, and never has this been more true than here and now. It is obvious for all to see that countries, in which science and technology are widely embraced and applied, are the countries that top the list in terms of growth and development.

Today, mastery of science and technology is shifting to Asia: this is, clearly, the most important message of the UNESCO Science Report 2010 recently launched simultaneously worldwide. Asia is now playing a significant role in the science and technology innovation of the world in terms of R&D investment, human resources and scientific output. Of course Asia is diversified and imbalanced in terms of culture, the development of the economy and S&T. Countries within the region are different, with different competencies and strategies for success, Nevertheless, I am convinced that – linked by history, geography, and by similar development challenges – they have important lessons to share, in particular with regard to the successes they have achieved. Some countries in the region have established high-quality research programmes. These countries are in a strong position to cooperate with others in developing effective science policies. Scientific communities of the Asian countries will be able to make their contribution for overcoming challenges and the development in Asia and the world as well.

It is my conviction that science and technology regional cooperation in Asia has huge potential issues and areas with wide prospects which will be beneficial for all participant countries. It is therefore very clear that the regional cooperation and coordination is the only way to face these common challenges and enjoy development in the era of globalization.

Another challenging aspect of the regional cooperation is the South-South cooperation dimension. Many developing countries have acquired excellence in many economic fields, ranging from manufacturing to information technology, modern agriculture to medical science, and management to scientific innovation. The expertise of such developing countries is often more appropriate to the needs of other developing countries. These developments, coupled with regional integration, have given a fresh impetus to South-South cooperation. More than ever before, it is clear that South-South cooperation combined with regional integration presents a benefit to countries regardless of their level of development and is also a necessity for countries that wish to address successfully transnational challenges.

Let me take this opportunity to recall the importance that UNESCO attaches to the crucial role played by the South-South Cooperation in promoting scientific research for development, in other words for solving the majority of the problems facing developing countries today, such as the need to increase agricultural productivity, to feed a growing population, the protection of the environment or the fight against disease. The International Centre for South-South Co-operation in Science, Technology and Innovation, which functions in Kuala Lumpur under the auspices of UNESCO, is an excellent example of a platform for exchange of experience and best practices in science and science policy.
I wish to begin with paying my obeisance to Dr. S. Husain Zaheer who was my doctoral mentor and was a great inspiration to me in my professional career. He was a strong advocate of Science-Society interfaces and used to emphasize that public R&D should, apart from original basic research for generation of knowledge, focus on critical societal needs such as food, healthcare and energy, and national causes such as industrial development, national security needs and economic development. As Director General CSIR, he initiated in 1965, the International Scientific Collaboration Wing and established bilateral programmes between CSIR and parallel scientific and technological organizations abroad, especially in the developing nations. He was a highly popular, charismatic and successful leader who mentored many successful leaders and left enduring legacies.

What are the attributes and concerns common to the countries in the South Asia and South East Asia Region?

First, The Oceans. Most countries are maritime states with access to marine resources, living and non-living.

Second, High Population Density. The importance of food and nutrition, their availability, quality and equitable distribution is a foremost concern.

The third, Cultural Similarities. Cultural processes play an enabling role in scientific cooperation. Tolerance and respect for other belief systems facilitate team work.

Fourth, Biodiversity. The region hosts biodiversity hotspots and rain forests and is a treasure of traditional knowledge.

Fifth, Human Resource. Sound educational institutions and S&T systems supported by research and development institutions are assets.

Sixth, Thrust on Industrial innovation and enabling public policies.

I would call these fundamental strengths of the countries of this region, offering a powerful and suitable backdrop to mount relevant joint endeavors. Let me give a few examples.

1. New Drug Discoveries

The United Nations Convention on the Law of the Seas bestows on the maritime States sovereign rights over the living and non-living resources in, on and under the sea in an Exclusive Economic Zone (EEZ) up to 200 nautical miles from the coast. For example, Maldives with a land area of just 300 square kilometers has an EEZ of 959000 sqkm. Sri Lanka’s land area of 65000 sqkm has an EEZ of 517000 sqkm. Bangladesh’s EEZ of 76000 sqkm exceeds its land area of 33000 sqkm.

The seas are known to be repositories of highly biologically active organisms and substances of value in the search for new drugs. A collaborative networked project to prospect, access, analyze, identify and evaluate prospective molecules should bring together many institutions and researchers as well as pharmaceutical giants. New drug discovery involves several disciplines and competencies (oceanographic vessels, natural products, chemistry, pharmacology, chemical engineering, drug development, regulatory processes) all of which are available in the region and can be linked.

Let us remind ourselves that in the top 20 best selling drugs in the world market there is not a single one from any country of the region, my country included. Here lies the challenge.
2. **Forest Fires**

The South Asia Region has been frequently ravaged by forest fires and transboundary haze causing serious devastation to public health, environmental quality and national economic activities, in addition to destruction of valuable biodiversity. Transboundary haze carries with it the risk of triggering more fires and also adversely impact climate change and the normal atmospheric processes. Though Australia, Canada, Russia and USA also experience forest fires they are essentially terrestrial. On the contrary, the SA and SEA Region presents a unique situation where sovereign nations are separated by short sea distances which introduces a new dimension of ocean dynamics in the spread and penetration of fires and haze.

There is, therefore, a need for networking the competent institutions and groups in the region and beyond, as necessary, to address the scientific dimensions of forest fires and transboundary haze, by engaging the full potential of mathematical modeling and computer simulations which could lead to the design of reliable advance warning systems and mitigation strategies.

3. **Industrial Zoning and Disaster Prevention.**

26 years ago India experienced the worst disaster in the history of chemical process industries in the world. It triggered worldwide concerns on the safety of chemical and allied industries and the need to strengthen nation’s capacity in risk analysis and emergency management. 26 years on, while there have been major advances in the engineering sciences to achieve increased process safety, many developing countries continue to use outdated, inefficient and risk prone technologies and are still to put in place the necessary steps and protocols in terms of land use planning, zoning, accident alerts and emergency management.

The social, legal and economic consequences of major chemical accidents are now well known. There are lessons to be learnt. I believe it would be useful to bring interested countries together in a conference to exchange ideas and identify short term and long term measures for industrial zoning, coping with technological change, and crisis management strategies.

4. **Tackling Sea Pollution**

The oceans of the world and the outer space are perhaps the last frontiers remaining to be explored and exploited by humankind. From the regional perspective, sustainable oceans management is, in my view, a matter requiring urgent consultations and actions. Tackling sea pollution should rank at the top. Sea pollution is increasing alarmingly both on account of accidental spills and from deliberate dumping of all kinds of wastes, hazardous and toxic wastes in particular. With maritime traffic slated to expand in the coming years it is easy to imagine the extent of pollution threats and their implications for livelihoods, public health and national economies.

Do the countries have the tools and expertise to tackle ocean spills and waste dumping?

Do you have the state-of-the-art analytical facilities for rapid and accurate detection and identification of the culprit substances and their traceability?

Is a regional emergency response service in place?

Is it not desirable to design relevant expert systems?

I have mentioned those which I thought require priority attention. Everyone of these would involve cross-disciplinary and interdisciplinary research and development. Institutions in the region
have the talent and attitude to come together and find solutions, associating competencies existing beyond the region as needed.

I am sure the Conclave will generate many more ideas for advancing science, technology and innovations.

My Best Wishes,
H.E. Shri Balmiki Prasad Singh
Address by H.E. Shri Balmiki Prasad Singh
Governor of Sikkim

Dr. Abid Hussain, Dr. Lidia Brito, Dr. Thyagarajan, distinguished delegates and friends.

At the outset, I join the organizers in warmly welcoming each one of you to this international meet. This Conclave is the third international conference in continuation of two previous ones held in 2005 and 2007 at Chandigarh and New Delhi, respectively.

I would also like to congratulate Zaheer Science Foundation and UNESCO’s South Asia and South East Asia Science Policy Forum in organizing this conference.

Personally, I feel deeply honoured to have been given this opportunity to address the Conclave of distinguished scientists and innovators. This morning I propose to offer some perspectives based on my experiences of public service for the last five decades both in India and at the World Bank to emphasize that science & technology have strengths to give our people a standard of living in order that our men & women, boys & girls could develop their personalities in terms of their genius.

Distinguished Participants

India was one of the first among the developing countries to adopt a Scientific Policy Resolution as early as in 1958 under the dynamic and visionary leadership of the first Prime Minister of India, Jawaharlal Nehru. It was he who relentlessly emphasized the youth of India as well as of other developing countries of Asia and Africa to inculcate among themselves scientific temper and rational way of thinking.

The framers of the Science Policy Resolution wanted its contents to form a basis for intensive discussion with scientists and educationists of the country so as to evolve plans and programmes to advance the interest of science and technology. Towards this it envisaged active support from non-governmental organizations like Zaheer Science Foundation.

In this background, Zaheer Science Foundation was established in 1970 as an NGO to help the Government departments in the promotion of scientific research and educational excellence activities. The inspiration for starting the Foundation came from the perception that there was a gap in the area of interaction between science and society and that the Foundation could bridge that gap to foster scientific attitude and temper, among the people.

As one who has observed the activities of the Zaheer Science Foundation for the last several years, I can say without any reservation that the Foundation is actuated by a strong commitment to serve the cause of science and technology as well as to promote regional cooperation. The Foundation, however, must ensure that in the context of the globalization of the economy which has thrown up new opportunities for the people world over to participate in the developmental activities, it should play a greater role in building an atmosphere of cooperation specially in the area of science policy and programmes to face future challenges.
Distinguished Participants

Science & technology have made great strides in recent decades. The promise of global transformation of scientific discoveries and innovations can have very positive role in finding solutions to many of the inherent problems of the developing countries such as poverty and disease. In a conference such as this we need to discuss and forge a relationship between science, man and development so that wherever we are, whichever country we belong to, our research should be oriented towards addressing the well-being of mankind at all times.

It may be recalled that even in the U.S. and Europe the standard of life of people rapidly changed only from the beginning of the 19th century on account of scientific and technological applications in agriculture, industry, medicine, architecture and education. Earlier most people in these countries also like those elsewhere spent their time on basic necessities of life – food, shelter and clothing.

We are conscious of the fact that all scientific inventions not only benefit the inventors but also the people at large. For knowledge is a public good. The use of scientific knowledge and instruments of technology do not decrease when it is made available for others. At the same time, private and social returns can be markedly different. In this context, I would like to mention about the benefits accruing to us from the use of information and communication technology.

In the context of ICT, the chief tool for change, undoubtedly, is the Internet which has helped bring about wholesale transformation in the edifice of our economics dominated civilization.

It is widely believed that it is only through the use of the Internet technology that social barriers can be overcome. India was for long dominated by the Brahminical culture, the higher levels of knowledge popularly known as the sacred knowledge was only in the hands of the Brahminical class, and the rest of the society was denied access to it. It is true that the entire society was integrated through the network of rituals that regulated birth, marriage, and death ceremonies. In today’s world any denial of use of the Internet to the masses would perhaps conform to a similar practice where connectivity through mobile phones would be available to everyone but vital information that is the preserve of the Internet system – linked to a land line telephone – would be confined to those belonging to a higher economic, social and educational strata. It is, therefore, vital that we move in the direction of creating habitats where access to the Internet is not dependent on a landline telephone and elsewhere we should lower the cost of such telephone connectivity. I am glad that new innovations are rapidly making the Internet available to the common people.

In coming years the status of a country in the comity of nations would be largely determined by the strength of its scientific manpower than by the strength of its arms.

Distinguished Participants

Our development experience clearly establishes that widespread use of science and technology will not take place because we assembled here want it, although this is a basic pre-requisite for such a thing to happen. In this context, it was Mahatma Gandhi who rightly instructed us to “be the change that you want to see in the world”.
In my view, a major requirement is to create a learning society. This is especially so today, as in the 21st century the world is rapidly moving towards becoming a knowledge based society. Our progress would largely depend on cultivation of science education and technological skills. The role of individual scientists would be of crucial value in this behalf.

A learning society cannot be accomplished merely by allocation of resources on education including science education. Besides, we have also to understand that adoption of right policies by itself will not secure us what we aspire for or what we need. We will have also to get our institutions right. We need to secure better governance and better management in the government run scientific institutions. We have to go beyond government to the market and to the civil society. Towards this the need is to sensitize scientists of government managed institutions in order that they can interact better with market and civil society organizations.

There is a greater need for closer cooperation not only between Parliamentarians, policy makers, scientists, industries and the media of a country but internationally also. The whole world is concerned about the challenges of ethical issues facing mankind in the fields of bio-engineering, alternative energy sources, the AIDS epidemic and exploitation of the scarce natural resources. These are not problems of any one nation or some nations but they are common to all who share this world. It is therefore imperative for nations to come together to share their scientific knowledge in such conference not only to improve quality of life but also for global safety and security.

It is said in many ways we have become products of science and technology, be it in medical advance or breakthrough in communication services or when we read about discoveries in food technologies and nutrition. These developments have changed our perceptions of quality of life, no matter where we live. But all said and done with constant exchange in ideas, discoveries and innovations we are well positioned to confront formidable challenges that we face today, collectively.

The developing countries must seize opportunities to improve their socio-economic conditions. On the other hand, the advanced countries prospering on the basis of their knowledge and superior technology should be willing to utilize the opportunities of cooperation of skilled and unskilled manpower, use of resources and raw materials of the developing countries so that the technology developed by them may be used for increasing production and well being of the people of developing nations. Such cooperation will benefit both the advanced countries and developing nations. Viewed in this background, such Conclaves should be held regularly with the participation of experts within the country and abroad.

I have no doubt that this Conclave would provide a productive platform for exchange of ideas and experience among the scientists of the region to chart out programmes suited to the needs of their respective countries in order to effectively meet the challenges thrown up by the globalization of world economy.

I am sure that for the next four days you would be able to have very fruitful deliberations and chart out a roadmap for bringing together scientists and innovators for promoting cooperation in all issues concerning development through science and technology in each of the participating countries.

Let me add the following five issues for your consideration:

- Globalization is a reality. It, however, does not inform all human activities at the same level or with the same intensity. While globalization has integrated markets and the banking system, it has yet to make a decisive impact on dialogue and cooperation between scientists and innovators either of a region or at the global level. This is a challenge and a conference of scientists like this one must
address it. Let this conference take note of this and work to help accelerate the pace of cooperation among scientists and innovators in the region and the world.

Talking about South Asia and South-East Asian region, the focus of this conference, we have to realize that it has several fundamental strengths like widespread oceans, rivers and wetlands, sunny days, rich bio-diversity and common cultural processes. The biggest strength perhaps lies in the fact that it is a youthful region. The youth of the region has developed both aspirations and as I see it a determination to move forward in tackling the problems of poverty, disease and backwardness that afflict countries of the region. How do we meet these aspirations at science and technology levels?

I sometimes wonder if the global scientific community had worked hard to develop solar energy technology in the past, the energy scenario in the region would have been totally different. It would have ameliorated the conditions of our people and we would have been at a higher level of development than at present. Would the scientists assembled here and outside pay attention to this aspect of energy generation and work with a speed that could enable us to catch up with the lost period of time?

Drinking water is a matter of concern. The question which bothers me with regard to drinking water technology relates to conversion of saline water into potable water. Major technology improvements in this field would go a long way in lowering costs of conversion of saline water to potable water and this would in turn ensure better availability of drinking water to the people. Let this conference take note of this issue and view it with urgency in the context that water has the potential to be a cause of conflict.

Several scientists and innovators are working in myriad fields of activity in different parts of region. It will be necessary that we have an institution which would serve the purpose of a regional information network of scientific innovators and their applications. Sharing such information would help avoid duplication of efforts and also enhance the level of co-operation among scientists and innovators. Zaheer Science Foundation and / or UNESCO’s regional forum could be such an agency.

It should, therefore, be our endeavour to nurture an atmosphere of innovation and creativity in the sphere of science and technology, through the process of co-ordination and sustained cooperation both among the scientists and at the level of leadership of industrialized and developing countries.

I wish the Conclave very productive and fruitful deliberations.
Address by Dr. Mohsin U Khan  
Secretary, Zaheer Science Foundation, New Delhi

There are several issues with regard to regional cooperation in science and technology. For an active operational network among South Asian and Southeast Asian Countries on Science & Technology Policy it is important to established Asia Network. Government attention is needed to promote higher education not only in India but in other developing countries as well through regional cooperation.

South Asia is a region of the world with growing economy and needs to be given a strategic importance. India, in particular, possesses a market of over one billion people, a well-developed high technology, industry and agriculture sector. It is also the world's largest democracy. In the early fifties and sixties India had established infrastructure of industry and science and technology. India is at great advantage with a large pool of scientific and technical manpower that holds third place in the world. In this era of globalization South Asian countries are catching up fast to boost their industrial development and science and technology skills to compete in the world market. For example, India has liberalized its market in a big way in 1991, it has given dividend in the form of highly developed pharmaceutical and automobile industry. In the current year 2009-10, She has exported software worth US $ 40 billion. The other South Asian countries like Pakistan, Bangladesh, Sri Lanka, Nepal and Thailand follow suit by announcing Information Technology policy which has given tremendous promotional push to this industry. However, still there is a need to strengthen R&D infrastructure in these countries because no country other than India spends more than 0.26% of GNP on R&D. If we have a look at the organization and structure of science and technology in these countries, the R&D institutional set up is very well established. The institutional framework has been influenced by relevant policy instruments to give boost to scientific research and innovation systems. However, the output in the form of publications, patents and innovations transferred to industry is not of international standards with the result industry is not able to compete globally. The other observation significant to mention here is, a large percentage of S&T activities are controlled by their respective governments whereas in the developed world it is just the reverse, majority of R&D is taken care of by private industry. The state should work as a promoter of R&D and industrial development and not as a producer. That is the reason efficiency and quality goes down. The other thing that has prevented the development of industry to the international standards is, they always look at the domestic market and never framed policies to promote exports not even in selected areas of economy. For example, Japan and Korea concentrated on few selected areas like electronics, automobile, biotechnology and pharmaceutical industries. Koreans had adopted export-oriented policies in the development of electronics industry. They have done everything possible to establish marketing network in the developed world to export their goods. One of the measures they have taken is Original Export Manufacturing (OEM). Under this contract they manufactured goods for the companies already having well established marketing network in the developed countries. For example, they have manufactured microwave ovens for Japanese company SHARP and sold it under its brand name. The other thing responsible for the success story of South Korea is that the four big conglomerates, Samsung, Goldstar, Hyundai and Daewoo got together and pooled their resources for the development of R&D in different sectors.

For developing countries, it is important to keep a balance between capital intensive and labor-intensive technologies, like India and China did in the past. Green revolution success in India is an
example of that, for high agriculture production one needs top quality fertilizers, high yielding variety seeds, pesticides, agricultural implements like combined harvester and tractors which are highly capital intensive in nature. India could never have been self sufficient in food if she had not gone for capital intensive technologies in this sector but on the other hand, one cannot ignore the poor farmers, therefore, there is a strong need to make certain modifications in bullock cart, using local fertilizers conventional seeds as well as conventional agricultural implements which is supported by labor intensive technologies. The developing countries should go for the technologies that are appropriate for them.

Open door policy is welcomed because it gives a chance to local industry to learn more from the multinationals and foreign investment can improve the deteriorating situation of less developed countries.

This chapter gives a review of the status of science and technology in India, Pakistan, Bangladesh, Nepal, Sri Lanka and Thailand. Each of these countries of South Asia have set targets to give a boost to industry and science and technology for the next five years.
Research Papers
Climate Change & Environmental Issues
If climate change and food matters to us,
We shall matter more to it!

Dr. V. Prakash, Ph.D, FRSC
Director,
Central Food Technological Research Institute,
Mysore, India

During the 1970’s the average consumption of grains in the overall composite food was nearly 65% as per the report of FAO. However, this has reduced to nearly 50% of the total food intake and the predictions for the year 2011 and beyond indicates that it can be much lesser now and therefore one is intrigued to ask the question Why Grain share of developing countries diet is shrinking? What are the Key factors? Climate change, how much it affects food production? What is the role of hotter climates in reducing the yield? What is the role of scientists in this data collection of the effect of climate change and the effect of it on food? How do we integrate global data with regional data? What is the next step to take and how can we look at the future with a clear passion of higher productivity and higher production and of course the social aspect of why people are eating less grains as per FAO statistics? There are many questions, perhaps and we may not have an immediate answer to all of them, but we need to be aware of these issues indeed.

We know from the scientific data that stress on plants, especially change in temperature and carbon dioxide levels etc. have shown that there is considerable decrease in the yield as the temperature increases. Similarly, if one indirectly compares rising atmospheric carbon dioxide to human nutrition, this directly indicates an imbalance in the plant stoichiometry. Therefore, intensive research is required to understand food production related to climate change through new management practices and newer ways of plant breeding and dissemination of improved germ plasm and cultivation techniques. With the data available currently, it is clear that climate change is not only about rising oceans, hot and cold pockets, drought and floods, but, it is also about the scientific ability for enabling the farmers to feed the dependent urbanites, since the urbanites cannot grow food in the cities! A true challenge indeed.

Further in a strange observation climate change may affect health through a range of pathways, for example as a result of increased frequency and intensity of heat waves, reduction in cold related deaths, increased floods and droughts, changes in the distribution of vector-borne diseases and effects on the risk of disasters and even directly affecting the malnutrition and related issues. The measures needed to combat climate change coincide with those needed to ensure a healthier population and reduce the burden on health services. A low-Carbon Foot Print Diet (Farm to Fork) and more exercise will mean perhaps less obesity, manageable diabetes and heart related diseases.

The impact of climate change on the economic crisis and the increase in food prices and an overall global food supply and the risk of higher hunger and malnutrition problems and even rather extending to food safety problems are all emerging unprecedentedly. For example, climatic condition which have grown by a few degrees higher temperature to many more degrees can have a different profile of infectious diseases in public domain and has a large and major role to play in public health. This indirect effect probably is not that easy to measure socially, because of the diverse group of agro production and the adjustment pattern of the population and also many other uncontrolled parameters for infectious diseases which do have an effect on solid life, but the trends are always to be seen and constantly analysed and needs dynamism.
As one talks about food, what are the forces that shape a food grid? Forces that shape a food grid are what we can really also include indirectly the energy grid which comprises of Government, R&D Institutions, Production units, Market and most importantly people and there are several issues such as Indigenous materials & energy resource, Socio-Economic imperatives, Internal & External markets, Fiscal policies, Human Resources, Trade & Economic blocks, Cost effectiveness & local sustainability and of course Sustainable Consumption. Therefore, combining nutrients for health benefits and formulation of food products with combinations of nutrients may provide greater health benefits with Food Safety and Security. Prevention of Food loss also means increasing availability of Nutrients and the climate change will have an effect on these patterns and need to be constantly analysed and proactively documented.

Water plays a major role in the area of food safety, especially from the point of quality, Safe Drinking Water Act, Public Water Systems and its distribution efficiency, the agricultural waste water, conservation and recycling of water. All these mean that today we need to ensure that this precious liquid is used carefully with all the global partnership of knowledge and networking of both its conservation and the safety of drinking water. Such a process has to be sustainable, protective enough and with a broader perspective of extending that to even Quality of Food Chain. Perhaps this is where primary processing is the key to success, as mentioned earlier with lesser productivity and lesser production which is combating farm losses. There is also a paradigm shift towards rural from urban, quantity to quality, production to process and policies supported by technologies and it is critical for the ever increasing population. Therefore, urbanizing food from rural should be “all inclusive” and must have Public-private-Intense-Partnership (PPIP). Ensuring food safety and quality at farm level production requires strategic network and a continuous awareness through Quality Literacy Movement. In other words, the information and communication technology has a major role in sustainable development and might even neutralize to some extent the effect of global warming for this sector. The paradigm shift of production by masses cascading into mass production with a Concerned Social Responsibility (CSR) is fundamental. A classical example of such an involvement in a rather unique and very unfortunate situation of Tsunami in India is the role that CFTRI played in alleviating hunger just in time by ensuring nearly 70 tons of processed food which was of traditional taste in nature to the affected areas in the coastal region of Tamil Nadu and nearly 0.2 million meals within 24 hours. This is a well-known documentation of how one should be prepared for disasters backed up with knowledge, but at the same time reaching the affected area in all swiftness.

In conclusion, even though there is a large amount of data available on global warming, at a local level, it is good to re-visit agricultural practices and strategic value additions for agri produce to generate value systems by a holistic approach of utilizing the agricultural by produce including co-product utilization. There are millions of people today, who cannot afford food and are completely immersed in malnutrition and hunger and in turn are prone to many diseases which of course are preventable through appropriate policy frame work at a global level. Many a time the local economies perhaps does not allow them to have access to food. But let us not have the excuse of global warming for not wiping out hunger, malnutrition and diseases, as with all the aspects of global warming, we can still afford to fight and overcome the three maladies of hunger, malnutrition and preventable diseases. This is especially so now that the younger generations are charged with more knowledge and empowerment to reach out. This is the confident optimism that India lives with and there is a greater responsibility for Scientists in this very important and challenging area of reach out in true spirit of Dr. Husain Zaheer’s vision with his extraordinary passion for Science and compassion for people. Indeed that’s the true spirit of Science Reaching People to improve Quality of Life.
Dr. S. Rajamani
Recent technological developments in cleaner production and green development for control of green house gas emission and climate change

Dr. S. Rajamani
Chairman
International Union of Environment (IUE) Commission
Chennai, Tamil Nadu, India

Introduction

The green house gas emission from degradable liquid and solid wastes which contributes nearly 50% of the carbon emission on the climatic change is not fully accounted and addressed in climate change issues. The domestic solid wastes in India and most of the Asian countries are generally collected without proper segregation and disposed into unorganized landfill or composting thus triggering to primary, secondary and tertiary environmental impacts. Highly degradable solid and liquid wastes generated from the abattoirs agriculture wastes (feed for the cattle, cow dung etc.), vegetable and fruit market wastes have large potential for biomethanisation and energy generation which are currently wasted to a large extent. In addition, the quantity of the degradable wastes gets reduced by 50% to 90%. There is potential for control of green house gas emission and converting them into useful energy. The digested residual sludge becomes a bio-fertilizer.

Development, operation and maintenance of centralized waste management systems to tackle liquid and solid wastes generated from major urban towns is one of the difficult tasks due to technical, socio–economic and logistic constraints. Though part of the domestic sewage is collected and treated in central treatment units, in towns major part of the domestic sewage and solid wastes generated from many residential colonies are yet to be tackled. This could be managed by decentralized wastewater management. Similarly, degradable organic wastes can also be managed in a sustainable and environmentally safe manner. With a view to ensure environmentally compatible and sustainable development on clean and green environment, demonstration projects for decentralized domestic and industrial wastewater and solid waste management have been developed for demonstration and dissemination under Clean Development Mechanism (CDM) in India.

This paper deals with the recent developments in conversion of degradable domestic and industrial wastes into bio gas and bio energy with case studies in South India.

2. Sources of liquid and solid wastes

The main sources of degradable solid and liquid wastes in India are from domestic and agricultural sources. They can be aerobically digested and converted into bio gas and bio energy. The bio energy can be used for heating, lighting and can be converted into electricity using gas engines.

The important sources of Liquid and Solid wastes in India are given below:

- Municipal Liquid Waste – 5000 million cubic m./year
- Municipal Solid Waste – 40 million tones/year
• Solid waste generation from 16 major cities – 40,000 tones/day
• Total community waste generation from rural areas – 15 million tones/annum
• Agricultural & animal husbandry waste from rural areas – 1700 million tones/ annum

The important degradable industrial wastes are as follows:
• Poultry waste
• Pulp & Paper Industry Effluent
• Leather and Slaughter house Industry wastes
• Vegetable Market Yard Wastes Sewage / Municipal Waste Water Animal Manure
• Starch and Tapioca Processing Industry Wastes

The general method of disposal of domestic and liquid solid waste are given below:
• Mixed Garbage from cities is collected and dumped in low lying areas in the outskirts.
• 90% of Untreated domestic wastewater & about 50% of industrial waste discharged into rivers, water bodies & wet lands.
• Pollution control norms not strictly followed on sludge & solid waste management.
• Open Lagoons cause green house gas emission.

These result in ground water and, surface water pollution, odour problems and land becomes infertile.

Currently less than 20% of the domestic liquid and solid wastes that too from major cities like Chennai, Delhi and other selected towns are collected and safely treated and disposed. Biomethanisation plants with the assistance of Ministry of New and Renewable Energy Sources (MNRE), Ministry of Environment and Forests (MOEF) and State Government Agencies have been installed for domestic liquid & solid wastes. Many biomethanisation plants for industrial wastes such as distilleries, slaughter houses, tanneries, sago factories etc. have been implemented and are in operation.

3. Performance of anaerobic reactors

The Up flow Anaerobic Sludge Blanket System (UASB) has been introduced for domestic wastewater treatment with biogas generation under Ganga Action Plan as early as 1988 to 1990. Many UASB plants are working for domestic wastewater and other industrial waste. Improvements and modifications have been made for anaerobic digestion of sludge and liquefied solid wastes. The overall retention time for liquid waste ranges from 6 hours to 24 hours. The detention time for solid waste ranges from 10 to 25 days.

Performance data of pilot scale anaerobic digester is given below:
• The performance of anaerobic digester in terms of reduction in volatile solids is 60 to 70%. The volume of the supernatant collected from the top of the anaerobic digester
using special liquid solid separator is more than 60% of the volume of the sludge fed into the reactor.

- The volatile solids are reduced by about 65%. The biogas generation is 80m³ per 100 kg of volatile solids. The volume of the sludge reduction achieved by the combined effect of anaerobic digestion as well as removal of clarified supernatant by solid liquid separation is 70 to 80%.

- The digested sludge contains less than 25% volatile solids with no foul smell and easily dewatered in sludge drying beds as well as in chamber filter press without any chemical addition.

- The supernatant from the reactor, which contains enzymatic effect, proposed to be used for biological liquefaction of waste fleshing from the leather industry.

- From the initial data, direct cost benefit analysis has been made in terms of reduction in sludge volume, cost of dewatering, final disposal of dewatering sludge, bio-energy generation and, the pay back period of the system ranges from 5 to 7 years. The main advantage is the operation of the anaerobic system under natural atmospheric condition.

    Waste animal fleshing after biological liquefaction can also be fed to the reactor to digest the liquefied contents for the biogas generation as studied and evaluated under a separate programme. The improved Anaerobic Sludge Digester with Liquid Separator is first of its kind adopted for degradable wastes.

36 mld capacity uasb system for domestic effluent with industrial waste, Kanpur
FIRST OF ITS KIND
4. Biomethanisation of abattoir wastes

A modern abattoir in Andhra Pradesh, South India has been set up by a Private Limited Company called AKEL Hyderabad. The slaughtering capacity is about 500 buffaloes and 1500 sheep per day. Solid wastes, to an extent of 60 Tons Per Day (TPD) are generated per day. The sources of generation of solid wastes include:

- Dung from animal holding area – 20 TPD
- Paunch content from the slaughtering area – 25 TPD
- Fat and grease – 5 TPD
- Agricultural residues – 10 TPD

The potential for biogas generation from abattoir solid waste is enormous due to its high organic content with no toxic substances. The feed material like gobar, paunch content can yield biogas of 0.75 – 0.90 m$^3$/kg of VSS destroyed.

The industry successfully implemented bio-methanisation of solid wastes. The solid wastes generated are collected in a dissolution tank. The dissolution tank is equipped with a mixer to completely mix the waste. The homogenized waste would pass through a macerator to reduce the particle size for effective biodegradation.

The homogenized waste is pumped into the digester. It is a high rate solid waste digester in which the homogenized waste will be treated under anaerobic conditions where the bioconversion of the organic material to the biogas takes place. The biogas produced is stored in a gasholder of 500 cum capacity from where it is compressed and sent to electric power generation.

The digested substrate is collected in a buffer tank from where it is pumped to filter press to dewater the solids. The dewatered solids are used as bio-manure. The press water is collected in a press water storage tank and pumped to ETP.

The residue from the biogas plant, which will be rich in nutrients, would be dewatered for use as manure. Thus it will be possible to use both the solid and liquid wastes profitably to generate power and bio-manure and make the slaughtering operation partly self sufficient in power utilization.
5. Gas Generation from Solid Wastes

The digester is effective in stabilizing the volatile solids in the feed to an extent of about 60%, with a biogas yield of 0.85 m³/kg of volatile solids destroyed. Approximately 2,000 m³ of biogas is being generated daily. Composition of the biogas is given below:

Gas Composition

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Composition</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Methane (%)</td>
<td>60 – 65</td>
</tr>
<tr>
<td>2.</td>
<td>Carbon dioxide (%)</td>
<td>35 – 40</td>
</tr>
<tr>
<td>3.</td>
<td>Hydrogen sulphide (%)</td>
<td>0.1 – 0.3</td>
</tr>
<tr>
<td>4.</td>
<td>Moisture (%)</td>
<td>Traces</td>
</tr>
<tr>
<td></td>
<td><strong>Calorific Value</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>LCV (kcal/Nm³)</td>
<td>4,800</td>
</tr>
</tbody>
</table>
6. **Bioenergy and biofertilizer from vegetable market waste**

Based on the experience with domestic and industrial wastewater and solid wastes a bio-methanisation plant has been implemented near Koyambedu vegetable / fruit/ flower market in Chennai. This is the biggest vegetable market in India. The commercial scale pilot bio-methanisation plant is designed to utilize about 30 tons of vegetable and fruit market waste and generate 2000 m³ of biogas. This biogas is converted into electrical energy (i.e. 2000 to 3000 units/day) and connected to Tamil Nadu Electricity Board (TNEB) power grid. About 4 to 5 tons of bio-fertilizer is generated from the bio-methanisation plant. The total cost of the demonstration project is about Rs.50 million (i.e. 1 million USD) with contributions by Ministry of New and Renewable Energy Sources (MNRE), Government of India and Chennai Metropolitan Development Authority (CMDA), Government of Tamil Nadu. Dr. S. Rajamani, Chairman, International Union of Environment Commission is the Chief Technical Advisor on behalf of CLRI for the implementation, monitoring and evaluation of the project, which is first of its kind in India and the system is operational for the past 4 years.

**Conclusion**

Climate control and Sustainable Development can be achieved by focusing on Bio-energy and bio –fertilizer from liquid and solid wastes, Green Development using treated effluents, Bio-fertilizer from solid wastes and Clean Development Mechanism.
Acknowledgment

- Acknowledgment is made for technical assistance by UNIDO, Vienna, Indo dutch project MNRE/ UNDP, MOEF, CSIR and other state and central government organizations, concerned industries and Alkabeer Exports Ltd. (AKEL) for implementation of the biomethanisation plant at AKEL with technical support of CLRI. The contributions of Chennai Metropolitan Development Authority (CMDA), Dr. T Ramasami, Dr RA Ramanujam, Mr. E. Ravindranath, Mr. R. Suthanthingan, Ms. Uma Maheswari, Ms. Chitra Kalyanaraman and Mr P Shanmugam, Scientists of CLRI are greatly acknowledged.
Persistent Toxic Substances (PTS) are chemicals that persist in the environment for long period, accumulate in the fatty tissue of living organisms and are toxic to humans and wild life. They can circulate globally and can cause damage wherever they travel. These chemicals have had unforeseen effects on human health and environment. These include carcinogenicity, reproductive impairment, developmental and immune system changes, and endocrine disruption thus posing threat of lower reproductive success and in extreme cases possible loss of biological diversity. Toxic chemicals, which are less persistent but for which there are continuous releases resulting in essentially persistent exposure of biota, raise similar concerns. The PTS commonly share the following characteristics; i) organic (including organometallic) substances, ii) slowly degraded in the environment, iii) accumulate in biota, and iv) toxic. The twelve persistent organic pollutants (POPs) often called as dirty dozen represent a subset of PTS, which is a broader concept than POPs. The UNEP POPs substances share many properties with the substances in the POPs Protocol under the Geneva Convention on Long-Range Transboundary Air Pollution (LRTAP) under the auspices of the United Nations Economic Commission for Europe (UNECE). An expansion of the list of the substances included in PTS was sought from there (Table 1) and under PTS program 28 chemicals were considered for the collection of global data and subsequent action (UNEP, 2003). The Stockholm Convention adopted on 22 May 2001 initially addressed the challenge posed by the 12 toxic chemicals listed as POPs, updated its list and 9 new POPs, were added for action. This includes lindane (γ-HCH) pesticide and its by-products α- and β-isomers large stockpiles of which are considered as wastes. UNEP PTS program after its global study is not viable and most of its activities are covered under POPs program that entered into force on

<table>
<thead>
<tr>
<th>Pesticides</th>
<th>Industrial</th>
<th>Byproducts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aldrin*</td>
<td>13. PCB*</td>
<td>27. Dioxin*</td>
</tr>
<tr>
<td>2. Atrazine</td>
<td>14. PAHs</td>
<td>28. Furans*</td>
</tr>
<tr>
<td>3. Chlordane*</td>
<td>15. PCP</td>
<td></td>
</tr>
<tr>
<td>4. DDT*</td>
<td>16. Chlordecone**</td>
<td></td>
</tr>
<tr>
<td>5. Dieldrin*</td>
<td>17. Hexabromobiphenyl**</td>
<td></td>
</tr>
<tr>
<td>6. Endosulphan</td>
<td>18. PBDE**</td>
<td></td>
</tr>
<tr>
<td>7. Endrin*</td>
<td>19. Chlorinated Paraffins</td>
<td></td>
</tr>
<tr>
<td>10. Lindane (γ-HCH)**</td>
<td>22. Organic Lead Compounds</td>
<td></td>
</tr>
</tbody>
</table>
11. Mirex*  
12. Toxaphene*  
13. Pthalates  
14. Octylphenols  
15. Nonylphenols  
16. Perfluorooctane sulfonic acid & Perfluorooctane sulfonyl fluoride**

New POPs  
α-HCH**  
β-HCH**  
Octabromodiphenyl ether**  
Pentachlorobenzene**

*Originally 12 chemicals (dirty dozen) listed under POPs program  
** Nine new POPs added in the list of dirty dozen

17th May 2004 and currently 172 parties are committed to the Convention. More so with revised POPs list except few chemicals all the chemicals identified under PTS are covered for action; therefore, in the following discussion examples of action taken under POPs activities will be cited. The Stockholm Convention targeted ban on the production and use of POPs in countries that have ratified the Convention (UNEP, 2005). A basic and early requirement of any country to meet its obligations as a Party to the Stockholm Convention is the preparation of a National Implementation Plan (NIP), and associated Action Plans to eliminate or reduce the release of POPs into the environment. Many least developed countries, however, lack the necessary capacity and skills to adequately develop such strategic plan. There are some inherent problems that developing countries are facing.

In developing countries the problems and needs for the management of PTS are; education & awareness amongst the populations, human resource development, information resources, uniform policies, laws and regulations, development of action plan, coordination amongst stakeholders, research and monitoring capacities, development of infrastructures, alternative measures, strategies and cleaner production technologies, financial resource management for implementation of action plan.

Awareness, Education & Training Program for developing countries

The basic problem in developing countries is the lack of awareness among different sectors of society, industry and policy makers about potential health effects of POPs. In many developing countries information about POPs sources and releases is not available. Most of the developing countries are agriculture based and agriculture being their main economic activity the use of pesticide is inevitable for better yields. To adopt and accept alternative methods require awareness and incentives. The data from wildlife in Africa and other regions show concentrations of POPs equal to or higher than those in temperate or cold regions. There are also occupational health problems related to the use of POPs in developing countries. Considering health, nutritional and educational status of the population strenuous efforts are needed to build up a cleaner and safer environment for a sustainable socio-economic growth. In order to develop national plan by each country United Nations Institute for Training and Research (UNITAR) on behalf of UNDP initiated in 2004 an action plan training/skills building for 25 least developed countries to assist with national implementation plan development under the Stockholm convention. Later 15 other countries were added in the list as a phase 2 program. The overall goal of the two projects was to provide national-level training, technical and financial support to least developed countries in order to develop and strengthen their skills to undertake project
planning, including Action Plan development. Skills building and training were combined with concrete follow-up activities on action plan development. The projects also contributed to human resource development through skills building in project planning and management. The objectives of the training included: raising awareness of relevant approaches to project and strategic planning; ensuring that trainees are able to effectively use key project management and strategic planning tools and methodologies; to apply these approaches in the context of the Stockholm Convention; and to share experiences and lessons learned between countries and identify possible country-driven follow-up activities.

**Regulations, Enforcement Capabilities and Illegal usage**

There is no single regulatory system that is in place for the entire group of POPs. In most of the countries regulatory management systems are in place for pesticides listed in POPs group but for unintended by-products, in general, no regulatory, management or monitoring systems are available. Developing countries are taking steps to adopt and strengthen national control regimes such as those existing in most developed countries. They are the signatories of most of the international agreements but strict enforcement is still a problem. Many developing countries in Sub-Saharan Africa, the Mediterranean, the Indian Ocean, Central America and the Caribbean, Central and North East Asia and South East Asia and South Pacific have laws and regulations but cannot enforce them. States facing low levels of organizational capacity and weak economies have serious difficulties in increasing environmental protection and fulfilling international commitments (UNEP, 2002 & 2003). Consequently, illegal usage of banned pesticides and uncontrolled release of combustion by-products PCDD/Fs is expected to cause serious problems. Investigations have shown that old stocks of chlorinated pesticides continue to be used in practice under no control of the authorities and that even banned products such as DDT are still being illegally imported in some of these countries. In many countries border controls are sometimes ineffective, which can lead to illegal trade in banned POPs. The infrastructure for chemical management and enforcement is often weak and compliance with regulations limited. Pesticide POPs often become a cheap and quick alternative for subsistence farmers with low levels of education and no modern equipment.

**Availability of Safer Alternatives**

Most of the POPs targeted by the Stockholm Convention are already banned or severely restricted in many countries for years or even decades. However, cost effective replacement chemicals and techniques are not available in many developing countries. A common perception also prevails in developing countries that alternatives to banned pesticides are ineffective. Many countries are in embarrassing situation because they tend to use what they can afford. This situation leads to the search for alternatives for use in both agriculture and vector control. The Stockholm Convention has taken the responsibility to stimulate the discovery of new, cheap and effective alternatives to the world’s most dangerous chemicals.

**The case of DDT**

"This pesticide harms health and the environment, but it is very good at killing and repelling the mosquitoes that spread malaria. In regions where malaria still poses a major health hazard, that is a huge benefit. Malaria kills at least 1 million people a year, mostly children, and mainly in Africa. Meanwhile, concern is mounting because the malaria parasite is becoming more and more resistant to the drugs traditionally used for treatment.

For years DDT has been sprayed in small quantities on the interior walls of homes as a relatively cheap and effective way of keeping malarial mosquitoes out and so preventing them from
biting people. Hardly any country still sprays DDT on crops, but over 20 use it for malaria control. During the Stockholm Convention negotiations it became clear that these nations are justly concerned that over-quick banning of DDT could have a high price in human lives lost to malaria”.

The Convention permits the production and use of DDT for controlling mosquitoes and other disease vectors in accordance with World Health Organization recommendations and guidelines and only when locally safe, effective, and affordable alternatives are not available. Use must be registered, carefully regulated and monitored at least every three years whether DDT is still needed for this purpose. Thus protection against malaria will not diminish. The Convention limits the production and use of DDT to controlling disease vectors such as malarial mosquitoes; it also allows DDT to be used as an intermediate in the production of the pesticide dicofox in countries that have registered for this exemption.

A GEF project in Mexico and Central America is providing alternatives to DDT. The project aims to prevent reintroduction of DDT for malaria control by promoting new mosquito control techniques. Nine demonstration projects are being created to show that methods to control malaria without DDT are replicable and cost-effective. In addition, the project is seeking to eliminate stockpiles of DDT, which pose a great risk of contaminating national and international waters. Similar projects are being developed for other malaria-prone regions of the world (GEF, 2006).

**Measures for Reduction**

Integrated pest management (IPM) appears to be the obvious alternative to reduce the use of chlorinated pesticides (UNEP 2003). The Global IPM facility has been created jointly by FAO, World Bank, UNDP and UNEP to establish participatory IPM programs in developing countries. The most important element of a successful IPM program is farmer participation and training. IPM should go hand in hand with the appropriate pesticide management to allow for regulation and control, proper purchasing and marketing, good technical quality and safe handling and disposal of pesticides (CEC, 2001). The available options for pest control consist a great deal more than the choice between chemical pesticides or the total exclusion of synthetic chemical inputs. Some of the strategies which improve pesticide management are:

- Replacement of the more hazardous pesticides with less toxic and less persistent ones.
- Selection of crop varieties which are more pest resistant.
- Improve pesticide application technology to minimize inputs and enlarge safety.
- Crop rotation
- Use of natural enemies for pest control.
- Cost-benefit analysis of the use of pesticides
- Farmer communication and consultation.

A successful IPM program has been put in place for cotton crops. Cotton crops amount for 25% of the overall pesticide consumption, hence improved pesticide management in cotton crops has a large impact on the release of pesticides (FAO). This would be particularly relevant for Egypt where cotton production is still quite extensive. The success of these IPM programs resides in the fact that farmers constitute the key decision makers in the process.
Disposal of stockpiles

Another important challenge for developing countries is to safely dispose of banned chemicals. A program for the disposal and handling of obsolete pesticides in developing countries has been initiated by FAO. Some developing countries require financial support to dispose of these stocks and replace them with chemicals whose benefits outweigh their risks. The Stockholm Convention calls on governments to develop and implement strategies for identifying stockpiles and products and articles containing POPs. Once identified, these stockpiles need to be managed in a safe, efficient and environmentally sound manner. It is not allowed to recover, recycle, reclaim, and direct reuse or alternative uses of POPs. Some countries have established inventories of pesticide stockpiles with the support of FAO. However, in most of the developing countries obsolete stockpiles of old chemicals are an important and difficult issue. Proper repackaging and in situ storage of the obsolete pesticides is required prior to their export to the appropriated thermal treatment facilities in developed countries. Safe storage on site is a preferred option in order to avoid the consequences of secondary pollution due to transportation and thermal treatment. African stockpiles program (ASP) adopted safe storage methodology in dealing with its estimated 50,000 tons of obsolete pesticides that has accumulated across Africa. The ASP supported by GEF seeks to clear all obsolete pesticide stocks from Africa and put in place measures to help prevent their recurrence (GEF 2006).

In developing countries cement kilns has been used for destruction of obsolete pesticides. A cement kiln possess many inherent features which makes it ideal for hazardous chemicals treatment; high temperatures up to 2,000°C, long residence time, surplus oxygen during and after combustion, good turbulence and mixing conditions, thermal inertia, counter currently dry scrubbing of the exit gas by alkaline raw material (neutralizes all acid gases like hydrogen chloride), fixation of the traces of heavy metals in the clinker structure, no production of by-products such as slag, ashes or liquid residues from exit gas cleaning and complete recovery of energy and raw material components in the waste. Kåre Helge Karstensen (personal communication) conducted a test burn with two toxic and obsolete insecticides in Vietnam in 2003. The gas sampling and subsequent chemical analysis was performed by an independent and accredited Australian test-house. The insecticide components fed to the kiln, Fenobicarb and Fipronil were not detected in the exit gas or any other sample collected during the test. The Stockholm Convention on persistent organic pollutants (POP’s) requires “complete destruction and irreversible transformation” of POP’s and POP’s waste as well as minimization and avoidance of emissions of dioxins, furans, PCB’s and Hexachlorobenzene during disposal. All these compounds, and many others, were analyzed in all samples but all the results were below the detection limit, showing that the destruction had been complete and irreversible, i.e. no new formation of dioxins, furans or PCB’s. However, not all kilns are suited without upgrading or modifications and the feasibility needs to be assessed in case by case. The author suggested that with nominal expenditure cement Kilns may be a suitable alternative for the destruction of hazardous chemicals/waste in many developing countries.

The case of PCB

PCBs present a different kind of challenge. PCBs can eventually be eliminated, but this will require additional money and know-how. Equipment containing PCBs is dispersed widely across the countryside, notably along electric power-line grids. Replacing all of this equipment immediately would be impractical and expensive, especially for financially strapped developing countries. Transporting PCBs to treatment sites is a delicate job that risks leakage and additional pollution, and the safe destruction or containment of PCBs requires special measures and high-tech equipment. With current technologies and facilities, only limited amounts can be dealt with at a time.
The Convention bans the production of PCBs but give countries until 2025 to take action to phase out the use of equipment containing PCBs. The recovered PCBs must be treated and eliminated by 2028.

For safe destruction of banned POPs alternative non-combustion technologies are also being developed. They are capable of high destruction efficiencies, taking into account emissions not only in air, but also in land and water. They are typically less expensive to deploy and easier to maintain at maximum efficiency than incinerators. Although effective non-combustion technologies have emerged in recent years, they have not yet been introduced in developing countries because of such barriers as lack of information and technical knowledge, limited vendors, and a need for supporting regulations and policy. Two GEF projects are showing how these barriers can be removed and exploring effective alternative technologies for destroying polychlorinated biphenyls (PCBs). This work is essential because currently there is almost no capacity to destroy POPs in the developing world. In the Philippines, a GEF project will demonstrate the viability of technologies to destroy PCBs without incineration. This technology will be used to destroy approximately 4,500 tons of PCB waste in the Philippines. The Philippine project complements a similar type of GEF project in the Slovak Republic. The latter will use another alternative technology to destroy approximately 2,500 tons of difficult-to-treat PCB manufacturing wastes and PCB-contaminated soils and sediments. This will reduce the amount of contaminants released from sediments into the Danube River Basin (GEF 2006).

The case of Furans and Dioxins

Emissions of dioxins and furans, the unintentional and unwanted is a serious problem and their reduction to zero using current technologies is difficult. In developing countries emissions from open burning of biomass like sugar-cane and forest fires are major contributors to the total dioxin inventory but very limited data on emissions from biomass burn is available. The number of experienced institutes are limited and sound scientific methodology for generation of emission factors is required that is accepted by developed and developing countries.

Monitoring Capacity

In most of the developing countries there is a lack of trained manpower and sophisticated equipments for the analysis of POPs. As identified during regional assessment of the persistent toxic substances the sub-Saharan African countries lack the analytical facilities in terms of high technology equipment, such as Mass-Spectrometry (MS), High Resolution Gas Chromatograph (HRGC) and High Pressure Liquid Chromatography (HPLC), in addition to recently developed efficient extraction and clean up equipment (UNEP 2006). A regional workshop was held in 2005 in the framework of the UNEP/GEF for English-Speaking African Countries to assess existing capacity and capacity building needs to analyze POPs in developing countries. Countries were asked to establish and agree upon requirements for laboratories to ensure adequate POPs sampling and analysis to support the implementation of the Stockholm Convention. The criteria include sampling, transport and storage of the samples and analysis (extraction, purification, separation, identification, quantification and reporting). The lack of skilled laboratory personnel to conduct the analytical work was identified as one of the critical problems.

A need was felt for training courses and annual training workshops for the transfer of technology and for that an arrangement was needed with countries having experienced personnel to assist developing countries for training of laboratory personnel. The maintenance of the analytical equipment was considered as one of the most important aspects. It is very expensive to have service contracts for all the maintenance and therefore it is important to provide training to the laboratory
personnel to do the basic maintenance when the QA/QC results are unacceptable. This is essential to generate compatible data from different laboratories for comparative reasons.

The Core Group Meeting (UNEP Chemicals) held at Amsterdam, 8 March 2007 proposed to categorize the POPs laboratories according to their performance and experience (UNEP, 2007).

The problems and needs for POPs management issues in developing countries discussed above suggest the need for the development of public awareness program to increase the knowledge about such dangerous chemicals. For their effective management uniform policies, laws and regulations and efficient implementation plan is needed. Coordination amongst developing countries is needed for research and monitoring capacities; sharing of knowledge for the understanding of regional factors affecting persistence and movement of these chemicals in the environment. POPs are global problem and their impact on the environment and risk to human health can be reduced by combined efforts.

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We will define development and subsequently we will define sustainable development for clean and green environment in the present century. We will summarize some ways that the science and technology will play its role in the development of present century. Production of energy and per capita expenditure of power by any country are considered to be important components of development in the present century. However, the present methods adopted have affected our environment appreciably increasing the emission of carbon dioxide resulting in climate change and global warming. The approach suggested world over is sequestration of carbon dioxide in the deep sea which is extremely expensive. We have suggested the plasma route to decompose carbon dioxide into its constituents and recycle carbon. There are some previous attempts by plasma route on decomposition of carbon dioxide but there is partial decomposition of carbon dioxide resulting into carbon monoxide which is highly poisonous. We will summarize some of these earlier attempts. We propose a scheme which uses an array of high voltage electrode system producing electric field with cross magnetic field and give some details of our approach to bring back the balance of carbon dioxide in the environment.

1. Introduction

Development of a country is indicated by human development index (HDI) which consists of life expectancy, education and per capita gross domestic product (GDP) etc of the country. In order to improve HDI it is necessary to increase production of energy and per capita expenditure of power by any country. Resources for energy production are mainly categorized into exhaustible and non-exhaustible. The exhaustible energy resources which are the main supply of energy production are vastly exploited in the last two centuries which results in carbon dioxide emission and radioactive waste material thereby affecting the ecology of the world. The inexhaustible energy resources are not widely tapped and are at times expensive. In the present scenario, we need to consider a ‘sustainable’ development which will meet the energy needs of the present without compromising the ability of future generations to meet their own needs for clean and green environment. From ancient times the approximate content of oxygen and carbon dioxide has been found to be between 210,000 ppm and 260 ppm respectively. This balance of oxygen and carbon dioxide content in the environment has been disturbed significantly due to the rapid increase in population and the consequent deforestation for catering the basic needs of this enormous population and industrialization. It is well known that industrialization needs an increase by per capita expenditure of power which results in the increase in burning fossil fuels, emission of carbon dioxide from vehicles, thermal power station and industries. The above mentioned reasons are the main causes of the rise in atmospheric carbon dioxide. The upper safety limit for atmospheric CO₂ is 350 ppm. This rise in atmospheric carbon dioxide can cause increase in absorption of long wavelength radiation reaching the earth which is not fully re-emitted. This may have localized effects resulting in climate change as well as global effects resulting in global warming. Therefore, the reduction of carbon dioxide to the safe level for all living beings is an important topic for many researchers. Two main techniques adopted for reduction of carbon dioxide level in the environment are carbon dioxide sequestration in which carbon dioxide has to be buried...
deep into the ocean or carbon dioxide decomposition by plasma methods in which it is to be decomposed into its constituents and recycled. Plasma is the ionized state of matter which may be partially or fully ionized depending on the energy supplied to it. Carbon dioxide decomposition will result in the reduction of the increase of carbon dioxide in the environment. In addition the reaction products in carbon dioxide decomposition will also help in potential utilization in metallurgy, organic catalysis and hydrogen production and also in restoring the natural carbon resources.

In this article we have summarized some of the earlier attempts of plasma methods for carbon dioxide decomposition such as plasma assisted thermal decomposition, dielectric barrier discharge, RF discharge plasma, tunnel type plasma jet for decomposition of carbon dioxide. However, in most of earlier plasma methods the decomposition of carbon dioxide into carbon monoxide is a major concern. Consequently we propose a scheme [1] for decomposition of carbon dioxide in which the carbon dioxide is decomposed to carbon and oxygen. In this scheme we use an array of high voltage electrode system producing electric field with cross magnetic field. We shall be discussing about this scheme in section 3.

2. Decomposition of Carbon Dioxide using Plasma Methods

In this section we discuss some of the plasma methods for carbon dioxide decomposition. One of the methods is reported by Huczko et.al [2], in which a plasma reactor consisting of a typical plasma torch attached to a quartz tube was used for carbon dioxide decomposition and is shown in Fig. 1. The plasma jet was generated by a d.c. arc discharge under atmospheric pressure.

In this experiment the thermal decomposition of carbon dioxide occurred in argon plasma where carbon dioxide decomposed into carbon monoxide and oxygen. The oxidation of the carbon monoxide begins but the further decomposition of carbon monoxide to carbon cannot be done using this method.

Radio-frequency (RF) plasma is one of the alternative techniques for the decomposition of carbon dioxide. Hsieh et al. [3] proposed an RF plasma technique for decomposition of carbon dioxide. Fig. 2 shows the main components of the Hsieh’s experimental equipment which include a vacuum pump, a gas introduction device (mass flow controllers), a RF power source (an excitation source producing electromagnetic radiation within radio frequencies for initiating and sustaining plasma) and a Fourier transform infrared (FTIR) spectrometer analysis system
An RF plasma reactor was used in the experiment and a cylindrical vessel having an outer copper electrode wrapped on the plasma reactor and grounded. A 13.56 MHz RF power is connected to the outer copper electrode. The gas mixture was introduced from the bottom of the reactor which flows through glass tubes into the powered electrode zone. Under specific conditions one can observe that the decomposition fraction of carbon dioxide was 60.0%, which occurs around 316°C.

In another study the decomposition of carbon dioxide using capacitive RF discharge was investigated by Sergey et.al [4] over a moderate range of pressures (5-60 Torr) in a flowing plasma chemical reactor. Pure gas (or a mixture) went through the discharge tube, and after cooling down to room temperature, the product gases were analyzed by mass spectrometer. The schematic drawing of the experimental setup is shown in Fig. 3. In this experiment two kinds of plasma chemical reactors were used. One of them was a Pyrex discharge tube cooled using air flow from a ventilator. The second one was a quartz discharge tube positioned inside the oil-filled glass tube. A 13.56 MHz radio-frequency (RF) source is used for producing output power from 0 to 300 W. In this experiment the decomposition of carbon dioxide is caused by direct electron collision via excitation of the unstable electronic state. Carbon monoxide was mainly produced from the decomposition of carbon dioxide.

Decomposition of carbon dioxide to carbon monoxide and oxygen in argon stream under atmospheric pressure has been investigated by Matsumoto et al. [5] using a dielectric-barrier discharge plasma reactor (Fig. 4). In this reactor the inner electrode was supported at the center by a quartz tube fitting. The quartz tube is used as the outer electrode tightly surrounded by a cylindrical jacket made by metallic aluminium. When an a.c. current at a high voltage was supplied into the argon stream, the homogeneous light of a cylindrical discharge was observed between the inner electrode and the quartz wall of the reactor tube. The carbon dioxide dissociation was found to proceed in accordance with the reaction $2 \text{CO}_2 = 2 \text{CO} + \text{O}_2$ at considerable rates, which increased with increasing the input voltage, the carbon dioxide concentration in argon, and the heat of oxide formation of the corresponding metallic component used as the electrode.

Fig. 3 Schematic drawing of experimental setup.

Fig. 4 Dielectric barrier discharge reactor.
Kobayashi proposed another scheme in which the plasma device used is a gas tunnel type plasma jet torch [6] shown in Fig. 5. In this case carbon dioxide is inserted from the center hole of the cathode nozzle. Two d.c. power supplies were used for the generation of the gas tunnel type plasma jet. Argon was the main working gas and carbon dioxide and hydrogen gas were added to the reaction. Various modifications to this device for the better decomposition of carbon dioxide are reported elsewhere [6-10]. One of the modification to this device is a confront electrode type plasma jet (Fig. 6). In this case, the distance between the two electrodes is gradually bigger in the direction towards the torch exit thus it is easier to adjust the location of the electrode spot than the conventional plasma jet. This enables the working gas as well as the plasma jet to flow in an axial direction. This makes it superior to other plasma jets in terms of reactive performance. The major problem of this method is to enhance the performance for the effective reaction such as dissociation of carbon dioxide and synthesis of CHx. The gas tunnel-type plasma jet was improved for a high-energy-type plasma jet shown in Fig. 7. The improvement was done in the ignition system (part A). The tungsten cathode for ignition was inserted from the hollow cathode of the gas tunnel-type plasma torch (part B) to the anode of the gas diverter nozzle before ignition, and pulled out after ignition by the high-frequency ignitor. Carbon dioxide gas was mixed with the working gas (argon) after the formation of the gas tunnel-type plasma jet. The experimental apparatus is shown in Fig. 8.

The plasma torch is located at the center of the end wall of the cylindrical vacuum chamber. For the generation of the gas tunnel type plasma jet, a DC power supply was used, and argon was used as the plasma forming gas. For the purpose of this investigation, carbon dioxide and nitrogen gas were mixed with the working gas. The experiment was carried out under a vacuum pressure condition. The control of the plasma parameter was possible by changing experimental conditions. The exhaust gas from the plasma jet was collected at the wall of the exhaust tube to the vacuum pump by the gas collector. From the measurement of carbon monoxide and carbon dioxide contents, the efficiency of decomposition of carbon dioxide by the plasma jet
was studied. The gas tunnel-type plasma jet was used to decompose carbon dioxide and the characteristics of this method were clarified by varying the plasma operating conditions.

The result revealed by the fundamental experiment was that the arc voltage of the plasma torch was increased with increase in the carbon dioxide mixing ratio. The thermal efficiency of gas tunnel type plasma using the mixing gas was 65-80%, as the mixing ratio was increased, higher efficiency was obtained. The thermal efficiency was increased as the power input to plasma torch was increased.

The result of the performance test of the gas tunnel type plasma jet for decomposition of carbon dioxide showed that the thermal efficiency using mixed working gas was about 65% when the working gas flow rate was 100 l/min with the carbon dioxide content of 20% in the working gas and the discharge current of I=100A. The efficiency of carbon dioxide decomposition by the high energetic plasma jet was determined at various conditions. The optimum operating conditions of the gas tunnel type plasma jet will enhance its performance and improve the decomposition process of carbon dioxide. A high decomposition ratio of carbon dioxide will be realized at low carbon dioxide content when high power plasma is used. On the other hand, the decomposition amount per unit power was increased with increase in the mixing ratio of carbon dioxide.

3. Proposed Scheme of Carbon Dioxide Decomposition

In the proposed scheme carbon dioxide emission is provided with sufficient energy to produce full dissociation and fully ionized plasma. Thus it is possible in the new scheme we can completely decompose carbon dioxide to its constituent carbon and oxygen by applying a very high potential to a three dimensional array of electrodes. The schematic of the proposed experimental setup is shown in Fig. 9. The figure shows a two dimensional array of electrodes horizontally arranged with alternating positive and negative terminals of high tension. Such arrangement is repeated vertically to cover the whole exhaust. The electrostatic shielding is maintained between each horizontally arranged electrode array. The electric field is in the horizontal direction of the chimney. Such a large electric field will dissociate carbon dioxide into carbon and oxygen which subsequently ionize into carbon and oxygen ions. The electrical energy to be supplied to the electrodes of the proposed scheme may be generated from solar power station. A constant magnetic field is applied in the vertical direction along the chimney. The magnetic field in conjunction with the electric field turns the carbon and oxygen ions in the direction perpendicular to both in the horizontal plane. The magnetic field provides different Larmor radii to carbon and oxygen ions which can be separately collected as is done in isotope separation of U²³⁵ from...
$^{238}$U. In addition, a similar scheme for carbon dioxide decomposition for vehicle exhaust is shown in Fig. 10. The difference is in the amount of decomposition of carbon dioxide as the amount of carbon dioxide to be decomposed for the latter is less. Thus the electric field required with few electrodes, powered by dynamo of the vehicle in conjunction with a transformer and the whole set up will be more compact as compared to the earlier proposed set up for chimneys for exhaust of thermal power stations.

References

Health Services
Promoting access to medicines through global co-operation: A new strategy through North-South collaboration

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Access to medicines and health care are the most challenging issues facing society today. While scientific knowledge and quality of health care have advanced exponentially over the last generation, millions of people around the world still die from preventable and curable diseases because they lack access to basic medicines and health services. Access to essential and life saving medicines especially for communicable, non-communicable and other diseases that affect the developing and poor world remain a global health goal. Access to essential drugs is also part of human right to health. Access to essential medicines depends on rational selection and use of medicines, sustainable adequate financing, affordable prices and reliable health and supply system.

This paper highlights a strategic solution through collaboration to improve access and more importantly through North-South collaboration. South countries with adequate R&D and advantage of technical competence of North countries to improve access and public health outcomes in least-developed and developing countries. Various modes of collaborations are suggested in this paper but the most appropriate and successful model of collaboration seems with generic industries of India because India is considered a pharmaceutical super power, and considered as global pharmacy. Indian pharmaceutical companies especially drugs for HIV/AIDS have captured global markets due to their ability to supply high quality generic medicines. Indian companies not only establish their businesses in America and Europe, but also sell many products to developing countries in Africa and South America.

Key words: Access, Generic Industry; Medicines, Collaboration, Communicable and Non Communicable diseases, developing countries.

Background:

One-third of the world’s population lacks access to essential medicines. In the poorest parts of Africa and Asia, this figure climbs to one-half. This global health and medicines crisis, among others, is the result of increased microbial resistance to older medicines, discontinued production of unprofitable existing medicines, and the prohibitive price of many drugs. In addition, very few new drugs are being developed to tackle major diseases affecting people in poor countries. Many other factors also contribute to the problem of limited access to essential medicines, including logistical supply and storage problems, substandard drug quality, and the inappropriate selection and use of drugs. Neglected communicable diseases also called diseases of the poor (including malaria, tuberculosis, schistosomiasis, river blindness, Chagas, sleeping sickness, leishmaniasis and HIV/AIDS) disproportionately affect the people living in resource-limited countries. Infectious diseases kill over ten million people each year, with the majority of these deaths occurring in the developing world. The leading causes of illness and death in Africa, Asia, and South America regions that account for four-fifths of the world’s population are HIV/AIDS, respiratory infections, malaria, and tuberculosis.
In 2000, the UN member states agreed to the United Nations Millennium Development Goals (MDGs) with the target of improving the health and welfare of those living in the poorest countries by 2015. It is significant that health figures in as many as three of the eight Goals. In many cases, it is the accessibility that is the issue to achieve these targets and there is a lot that needs to be done. So, while some significant progress is being made towards meeting the targets in some of the affected countries, in many cases progress is patchy, too slow or non-existent. Achieving the MDGs will require sustained and concerted global action. While States have the primary role and obligation to improve global health, other actors, including the pharmaceutical industry can and should play a role: developing innovative, safe and effective medicines and working with other stakeholders especially States to make them available, affordable and accessible to people who lack them. In May 2000 big pharma giants Boehringer Ingelheim, Bristol-Myers Squibb, GlaxoSmithKline, Merck & Co., and F. Hoffmann-La Roche Ltd. and Gilead Sciences and five UN organizations viz. United Nations Population Fund (UNFPA), United Nations Children’s Fund (UNICEF), World Health Organization (WHO), World Bank and the UNAIDS entered into a partnership to address the issue of lack of access and affordability of HIV medicines and to work together to increase access to HIV/AIDS care and treatment in developing countries. Therefore, a partnership was established in May 2000 in the field of HIV/AIDS to accelerate access to care and treatment for HIV/AIDS. The Accelerating Access Initiative (AAI) is a public-private partnership with GSK, that offers a good example of establishing a strategy to improve access to health care, including prevention and treatment technologies and tools. Under the programme AIDS Vaccine for Asia Network (AVAN) the collaborating activities are expanding in a way to focus more regional role in developing HIV vaccines (See Table no: 1)

**Introduction:**

India plays a vital role as one of the global leaders in the production of generic medicines. However, it also has the largest numbers of people without access to essential medicines. Over 1.7 billion people, mainly concentrated in Africa and India, do not have access to essential medicines The World Medicines Situation Report (2004) of the World Health Organization (WHO) says about 67 per cent of the population does not have access to essential medicines. As per the National Health Accounts of India (NHAI), the government expenditure on health as a percentage of total health expenditure is 17.9 per cent, while private expenditure is 82.1 per cent. Furthermore, drugs account for nearly 70 per cent of the expenditure on health in an area which has seen a decline in governmental spending. In India, lack of purchasing power is one of the main reasons for poor access to medicines, a situation worsened by a poor public health delivery system. Besides this, public spending on research and development of medicines has been abysmally low. It has been observed that the global investment in research & development (R&D) for neglected diseases covers 31 neglected diseases; 134 product areas for these diseases including vaccines, diagnostics, microbicides, and vector control products and Platform technologies. Total funding for R&D of new neglected disease products in 2008 was $2.96bn ($3.09bn in unadjusted 2008 US$ an overall increase of 15.5% on reported funding for 2007/$2.56bn).

As in 2007, three diseases captured the lion’s share of funding, together accounting for nearly three-quarters (72.8%) of global investment: HIV/AIDS ($1,164.9m, 39.4%), malaria ($541.7m, 18.3%) and tuberculosis ($445.9m, 15.1%). Leprosy, rheumatic fever, trachoma and Buruli ulcer again received minimal funding, less than $10m (<0.4% of global funding) each; while the remaining neglected diseases or groups of diseases secured between 1% and 5% of total funding each: kinetoplastids ($139.2m, 4.7%); diarrhoeal diseases ($132.2m, 4.5%); dengue ($126.8m, 4.3%); bacterial pneumonia and meningitis ($90.8m, 3.1%); helminth infections ($66.8m, 8m, 2.3%) and salmonella infections ($39.5m, 1.3%). 23.2% of global funding was

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invested internally by public research institutions and private companies, with the remainder granted externally to either product development partnership (PDPs) and intermediates, or directly to researchers and developers. PDPs continue to play a key role, managing just under one fifth (19.6%) of global grants in the neglected diseases R&D field.²⁶

It is therefore a complex issue that needs to be addressed from all dimensions. Some of the major concerns are as under:

1. **Unavailability of new health products:** It is well known that the pharma industry is not interested in drugs, diagnostics and vaccines for diseases of the poor as there is not enough market for these drugs and therefore not enough profits for the industry. Most of such drugs are purchased by the govt. for public sector use and therefore the price is not market-driven. According to MSF investigation, out of 1,393 new drugs approved between 1975 and 1999, only 13 were indicated for tropical disease-an illustration of just how large the “drug gap”.⁸

2. **Funding for R&D to develop new products:** Investment in research and development (R&D) to address the growing health needs of people in developing countries are of serious concern. The expression ‘10/90 gap’ has since become a symbol of inequity in global expenditures on health research. The 10/90 gap is the disequilibrium within health research whereby only 10% of global health research is devoted to conditions that account for 90% of global disease burden, especially by poor countries⁹. For example, during 2001, the total estimated global R&D funding was about US$ 106 billion of which 44% was from the public sector and 56% from the private sector. Interestingly, of this funding, as much as $101.6 billion was spent by the public (44.1%) and private (49.1%) sectors of developed countries. A mere 4.0% of the total (about US$ 4.3 billion) was spent by middle and low income countries on health research almost equally shared between public and private sectors¹⁰ where three-quarters of the world population live. It is therefore unreasonable to expect large R&D from either the public or private sectors of the developing countries. This should be done either by the developing countries themselves or in the form of South-South partnerships or other innovative mechanisms.

3. **Inadequate health R&D and other infrastructure:** Many poor countries like India do not have well developed health care infrastructure as the health problems are too many and the health budgets are always limited. Among the most critical limitations in the health care infrastructure are inadequate funds to purchase drugs, vaccines, diagnostics required for the multitude of diseases. In addition, the vast outreach required in these countries require the presence of that qualified medical and trained and skilled para-medical personnel to ensure that the care is given as per the prescribed procedures. For example, if there is an anti-TB programme, the health workers should ensure compliance by the patients receiving free drugs. Otherwise, there is a serious risk of drug resistance being developed resulting in multi-drug resistant cases that are more difficult to handle.

4. **Technological competence of poor countries:** To address the core issue of development of new health products for developing countries, both short and long term strategies are required. The technological competence of middle and low income countries is quite different as developing countries like India, Brazil have reasonable innovative capacity and competence in R&D both in fundamental research as also drug development. In fact, they have a strong generic industry that has been developed in the pre-TRIPS era. These countries now supply cheap drugs for most of the developing countries, as new drug development is a very expensive proposition with an estimated cost of about US$ 1.0 billion to bring a drug to the market. So even if some countries have the necessary R&D capability in public-private sector these countries cannot on their own develop new drugs and
other public health products. There is a need for some networking and collaboration between partners in the North and the South.

Collaboration with developing countries can also be directly beneficial to northern countries. When developed countries experience economic recession, they should pay attention to global opportunities to help them survive hard times, as South-North collaboration can give firms in developed countries increased market access to developing countries' markets. This helps mitigate the losses they might experience in difficult economic conditions in their own countries. But they can also go further and collaborate with developing countries' firms in the research and development stages of their health biotech activities, thereby lowering the cost of getting products on the market. It is important that firms, researchers and governments all over the world realize that opportunities in the health biotech field are not confined to a handful of northern countries and that a global approach is required to advance the development of this field.11

Networking and partnerships are now increasingly recognized to be the most appropriate and strategic option especially north and south collaboration. The collaborators belong to Government, Academia, Industry and Voluntary agencies/NGOs either from south or north. Collaboration depends on the objective, strength/weaknesses and requirement of each collaborator. A significant strategy for combating poverty-related diseases has arisen through need for the development of vaccines and drugs for diseases of the poor. However, to ensure its efficacy it needs to be set within an integrated delivery programme and sustained by well-defined organizational and management strategies. Policy measures thus need to recognize the strengths of clinical and non-clinical approaches to the management of poverty-related diseases.12

The term “Southern” denotes the collaborators primarily based in the developing world, and the term “Northern” signifies to those working principally in developed countries. The principal actors in collaboration may be between Govt. to Govt. of north and south especially for discovery and development in both North & South and both countries work in a partnership mode for R&D and technology development and sharing. Some important public sector partnerships and government driven include Indo-US Vaccine Action Programme13, Indo-US Maternal and Child Health Initiative 14, Indo-US Initiative on NCDs by ICMR 15 etc where primarily institutes of government collaborate with similar laboratories or universities from abroad.

The other mode of partnerships may be collaboration between federal Government and industry either from north or south. The main focus of such partnerships is to conduct the clinical trial or development at south on the discoveries made at north. For example, HIV/AIDS vaccine development and testing through International Aids Vaccine Initiative16, HPV vaccine Gardasil of Merck north based industry and clinical trial by ICMR federal agency for health research in India.15 Some foundations have taken the initiative to access of low cost medicine like DNDi 17, One World Health, Concept Foundations and Medicine for Malaria Venture.18 Pooling of patent is a recent innovative collaboration between industry to industry from north and south. UNIAID is facilitating this collaboration to provide patented drugs for HIV/AIDS at low cost and make accessible to the HIV/AIDS patients.25

Product-Development Partnerships (PDPs)

The PDPs provide a framework for cooperation between the public (governments, academic and research institutions) and the private sector (companies, NGOs, and philanthropic organizations like the Bill & Melinda Gates Foundation). This is a working model, which enables both industry and government to do what they could not do alone. Several not-for-profit PDPs, including the
International AIDS Vaccine Initiative (IAVI), the Medicines for Malaria Venture (MMV), the Global Alliance for TB Drug Development, and the Drugs for Neglected Diseases initiative (DNDi), have been set up during the past 15 years. Although only 13 of more than 1,393 drugs developed between 1975 and 1999 were for neglected diseases,8 PDPs have created 143 candidate products in development over the past decade and have rolled out 11 products.19 Established PDPs like DNDi-Sanofi Aventis and DNDi-Brazilian Farmanguinhos/Fio-cruz have resulted in artesunate-amodiaquine (ASAQ) and artesunate-mefloquine (ASMQ) antimalarial fixed-dose combination products, respectively; TB Alliance-Tibotec will expedite the development of new TB drug TMC207; and DNDi-Merck partnership is working on drugs for leishmaniasis and Chagas. Sustainability of PDPs can further be enhanced if governments also join these efforts to support. Once candidate molecules reach the stage of clinical development, the most expensive phase of drug and vaccine discovery, public sector support could be provided. Inherently, plans for a fund that would channel, from governments and other donors, billions of dollars a year into PDPs were just put forward jointly by IAVI, Novartis and the Sidney-based George Institute for International Health.19

**Medicines Patent Pool Foundation (MPPF):**

Pooling of patents is one of the practical and effective strategies where combinations of drugs are required for a disease condition and the patents are owned by more than one company/institute. Providing access to HIV/AIDS drugs through patent pooling is a classical example. However, only the US National Institute of Health (NIH) has agreed to license the first patent for antiretroviral medicine-darunavir to the Medicines Patent Pool Foundation (MPPF). The Patent Pool when functional should facilitate the production of improved combinations of medicines for HIV, including better treatments for the 2 million-plus children living with HIV, who desperately need better medicines. It will also drive down prices. Other pharmaceutical companies should follow the NIH lead and contribute their patents on antiretroviral medicines to the MPPF to facilitate ready access to the HIV/AIDS drugs to the poor.

**Contract Manufacturing Services**

The global pharmaceutical market is estimated to represent a $48 billion opportunity for India by 2007 27 in terms of manufacturing outsourcing-supply of active pharmaceutical ingredients (APIs) and intermediates, development outsourcing-conducting pre-clinical and clinical trials and customized chemistry services-contract research services for compounds pre-launch worldwide revenues for pharmaceutical industry contract manufacturing and research services (CRAMS) totalled $100 billion in 2004 and will grow at an average annual rate of 10.8 percent to reach $168 billion by 2009.27 Within this total, the global market for contract manufacturing of prescription drugs is estimated to increase from a value of $26.2 billion to $43.9 billion, although the over-the-counter medicines and nutritional products sector will show the fastest growth. (Pharmabiz. November 24, 2005). Indian firms that will not have the ability to invest in R&D will be able to exploit the strengths they have developed as the world's leading suppliers of affordable essential drugs (Table no: 2).

**South-North Industrial Collaboration:**

In the areas of health and biotechnology, substantial benefits can be accrued from collaboration between partners in high-income (developed) and low- and middle-income (developing) countries, or what is known as 'the North and the South. Such collaborations can also minimize costs due to shared risks because expenditures for R&D and clinical trials are typically lower in the South than in the North. North-South collaborations can also facilitate access to strategic knowledge and resources. This flow of resources is not solely from the North to South. Developed countries can be the providers of
knowledge but developing countries have also been increasingly enhancing their expertise in this field and possess other resources, such as indigenous materials, important for health biotech development. In addition, South-North collaborations can open partners access to larger global markets. For developing countries, this strategy can facilitate access to the rich markets in the North and the emerging market opportunities in the South as well. For example, the economic growth and growing middle-class populations of such countries as China and India are creating an increased demand for resources from abroad. In 2025, the urban middle-classes of China are expected to reach 612 million, increasing their spending fivefold to more than $2.3 trillion a year. In addition, many developing countries have huge numbers of poor people who, because of the sheer numbers can be a great market opportunities, if the products are made affordable.

One example of such a South-North collaboration is between the major public sector biomedical institution in Brazil, the Oswaldo Cruz Foundation (Fiocruz, Rio de Janeiro, Brazil), and the large US biotech firm, Genzyme (Framingham, MA, USA). In July 2007, the two agreed to come together for drug discovery in neglected diseases—Fiocruz uses its bioinformatics expertise to identify novel drug targets in *Trypanosoma cruzi*, the causal agent of Chagas disease, which are then tested by Genzyme against its high-throughput screening libraries. The node in the Figure indicates the size of total number of South-North collaborations for the country, whereas the width of the lines represents the number of collaborations between two linked countries. Only linkages of three or more collaborations are included in the Fig.

**North-South firm collaborations in the health biotechnology sector**

In the area of health biotechnology, several companies in North America and Europe have increasingly started looking for partners in the developing countries for new collaborations. From the Fig it can be seen that China-US and India-US collaborations are strong, reflecting the strength of the USA in the area of biotechnology both in terms of number of companies and revenues11. The US still has linkages with biotechnology companies of Cuba despite trade embargo issues.
From the Fig it can be seen that the extent of South-South collaborations are substantial with over a quarter (27%) of the health biotech firms reporting this kind of collaborations. South-North collaboration is still more predominant, however, with over half (53%) of the firms reporting collaborations with developed countries. About 21% of the companies samples were reportedly engaged in both South-South and South-North collaborations. A total of 41% of the firms in the developing countries, reported that they had no international collaborations. Collaboration in health biotech is therefore roughly twice as likely to be along the South-North axis as the South-South one.

Public sector collaborations between North and South

The collaboration between governments of developed and developing world also exploit the opportunity to address the issue of access to medicines for the poor. The Europe and Developing Countries Clinical Trials Partnership (EDCTP) is a unique collaboration amongst 14 European Union countries, Norway, Switzerland and 47 sub-Saharan African countries that seek to overcome the three main poverty-related diseases: AIDS, malaria and tuberculosis. Since its launch in 2003, it has already achieved advances in research and innovation which has benefited the people of Africa that has been one of the world's worst-affected regions. The EDCTP aims to accelerate the development of new or improved drugs, vaccines and microbicides against HIV/AIDS, malaria and tuberculosis, with a focus on phase II and III clinical trials in sub-Saharan Africa. The EDCTP-EEIG member states: Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom support over 200 projects, among which 50 clinical trials, to fight against HIV/AIDS, malaria and tuberculosis in Africa. A new formula for fixed-dose medicines for young children infected with HIV was created. The EDCTP aim to establish a true North-South partnership between research institutes as it is not easy to conduct clinical trials without the support of professionals engaged in the African health care system.

Industry and Govt. Collaborations from North and South

Some MNCs are also engaged in the development of new drugs for diseases of poverty and have initiative partnerships with the governments of South. The Swiss based company Novartis established the Novartis Institute for Tropical Diseases (NITD) in Singapore in 2003. The NITD works with local and international researchers - as well as Novartis research centers - to develop medicines to combat rapidly spreading conditions such as dengue fever, malaria and tuberculosis. .The NITD was set up as a public-private partnership between Novartis and the Singapore Economic Development Board (EDB) in 2002. Since then, it has grown to more than 100 researchers and supporting staff to conduct Target discovery, Screen new compounds, Compound optimization, Preclinical development and Proof-of-concept clinical trials. NITD made the partnerships with other agencies for disease and domain specific work. These partnerships are Singapore Dengue Consortium for Dengue, Global Alliance for TB Drug Development for TB: Hasanuddin University Clinical Research Initiative (NEHCRI) for clinical research. The resources are allocated from the Bill and Melinda Gates Foundation, Wellcome Trust, Singapore Economic Development Board and Medicines for Malaria Venture.

Development programmes by the foundations.

The international foundations are also established to carry out research and development and product development for neglected disease. The basic objective of these foundations is to narrow the
gap between north and south through partnerships either for evaluation of new molecule, clinical trials or product development.

Programme for Appropriate Technologies for Health (PATH) - PATH is an international, nonprofit organization that aims to create sustainable and culturally relevant health solutions to advance acceptable and affordable new technologies for poor countries. A vaccine demonstration program with the partnership of GlaxoSmithKline and Merck & Co has been initiated for Human Papillomavirus (HPV) vaccine. Both companies have developed HPV vaccines against cervical cancer and are working with PATH to conduct pilot HPV demonstration programs in adolescent females in India, Peru, Uganda, and Vietnam with support from the Bill & Melinda Gates Foundation. The vaccine trials will address issues such as acceptance, accessibility, and adapting vaccination schedules to fit within the school year to encourage more young women to get vaccinated. In a major new collaboration announced at Clinton Global Initiative Annual Meeting, Merck and QIAGEN will collaborate to accelerate access to cervical cancer vaccination and screening in developing countries. Also, Merck & Co., Inc. and QIAGEN N.V. recently announced their intent to collaborate on a new programme to increase access to HPV vaccination and HPV DNA testing in some poor countries. GARDASIL has received WHO prequalification and is approved for use in 112 countries.

Collaborations of Indian generics with Multinationals

Indian generic companies play an essential role to enable access to affordable medicines for the majority of people within the Indian market and in most developing countries. The Indian domestic pharmaceutical market size is estimated at US$10.76 bn for 2008 and is expected to grow at a high annual growth rate of 9.9 per cent until 2010. Currently, the Indian pharmaceutical industry ranks 4 in terms of the volume and 13 in terms of value. The country accounted for 8 per cent of global production and 2 percent of world markets in pharmaceuticals. Globally India is known as a country that produces the cheapest drugs.

Indian companies have now begun forging new alliances with MNCs. These collaborations are helping to shepherd Indian drug companies into a new era of innovative drug discovery. Indian generic manufacturers supplied more than 80% of donor-funded AIDS medicines to developing countries in the last seven years, confirming India's status as the pharmacy of the Third World. The role of Indian generic manufacturers in supplying antiretroviral medicines to developing countries was done by UNITAID, an international facility for the purchase of drugs against HIV/AIDS, malaria and TB. In 2008, India-produced generics accounted for 91% of paediatric anti-retroviral (ARV) volume. AIDS treatment has experienced startling progress over recent years; with about four million people starting treatment between 2003 and 2008, largely due to India's ability to produce low-cost quality medicines, said a UNITAID statement.

Partnerships for HIV/AIDS- The Current HIV/AIDS scenario in India is quite grim with an estimated 2.4 million people living with HIV/AIDS (PLHA) in 2008 just behind South Africa and Nigeria. The anti-retroviral drugs (ARVs) remain the many stay of global HIV/AIDS treatment. The major originator companies for these ARVs are: Abbott, Boehringer Ingelheim (BI), Bristol Myers Squibb (BMS), Gilead, Glaxosmithkline (GSK), Merck, Pfizer, Roche, and Tibotech. In India about 30 ARVs are available as generics manufactured by Aurobindo, Hyderabad, Cipla Ltd Goa, Emcure Pharmaceutical Pune, Hetero Drugs Hyderabad, Macleods Pharmaceutical Daman, Matrix Laboratories Nashik, Ranbaxy Sirmour, and Strides Arco lab Bangalore. The major issue continues to be the impact of TRIPS-complaint legislation on access to ARVs to HIV-infected persons in resource-limited countries. A dual approach that could be considered will ensure the continued availability of high quality generics by manufacturers from India and elsewhere;
and ii) encourage strong efforts towards developing new generics from patented drugs and new formulations through newer global strategies. For example, the US FDA has approved, under PEPFAR, several generic antiretroviral preparations for purchase and use outside the United States. There have been a few efforts by the originator companies, under intense pressure on their pricing policies, to license the ARV drugs to mostly generic companies in the South. Table: 5, shows data on licensing of ARV drugs by the originator companies to non-US companies, mostly in South Africa, other African countries and India. GSK has licensed to maximum companies outside the US – 4 companies in the African continent. The BMS has licensed its drugs stavudine and didanosine to over 49 countries including India. Some companies like Gilead have licensed manufacture of its drugs to a large number of generic companies in India through non-exclusive licensing. (Table no: 4)

Concluding Remarks:

For ready access to medicines combination of two main concepts are necessary availability-geographical access, affordability-economic access, and access to technological level, that relates to emerging technologies in general, as well as more specifically changes in drugs and new treatment guideline to enhance the rational use of drugs. Most importantly, it is possible for long-term north-south partnership commitments to yield fruit and to strengthen the capacities of public health research in less developed countries. Providing affordable health care is inevitably a difficult task and stakeholders such as the Government, industry and civil society, with their varied interests and roles, have important responsibilities in this regard. Considering the disease burden and the abysmal state of public health facilities, the issue of access to affordable and quality medicines must be urgently addressed by the Government. The public health policies of the Government have an important bearing on access to medicine. A wide range of factors have significant impacts on access to medicine: the emerging international economic order, the intellectual property regime, regulatory frameworks, research and development policies, the business models of pharmaceutical companies, branding and pricing strategies, domestic and international trade in medicines, etc. Therefore, there is a need for a holistic understanding of the factors that impede access to medicine. In this context, the issue of access to medicines ought to be viewed in totality, through an approach that touches local, regional, national, and international levels. There can be no one-size-fits-all model for any intervention strategy for access to affordable and quality medicines worldwide.

Our analysis is indicative of North-South research partnerships, which testifies to the central role that research cooperation continues to play in generating knowledge in support of development and poverty reduction. North-South research partnerships are considered powerful tools for contributing both to knowledge generation and capacity building in the South, as well as in the North. Therefore it is necessary to think and implement a global strategy on access to drugs with the developed and developing countries jointly working as key partners both at the global and country levels to identify a concrete and pragmatic action plan to implement the strategy.
References:

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15. Indian Council of Medical Research (http://www.icmr.nic.in)
16. International Aids Vaccine Initiative www.iavi.org
17. The *Drugs for Neglected Diseases* Initiative (DNDi) http://www.dndi.org/
18. *Medicines for Malaria Venture* | MMV www.mmv.org
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Table no: 1 AIDS Vaccine for Asia Network (AVAN): Expanding the Regional Role in Developing HIV Vaccines

<table>
<thead>
<tr>
<th>Country</th>
<th>Vaccine</th>
<th>Sponsor</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>Adeno-virus</td>
<td>IAVI</td>
<td>Phase I</td>
</tr>
<tr>
<td></td>
<td>MVA</td>
<td>IAVI</td>
<td>Phase I</td>
</tr>
<tr>
<td></td>
<td>AAV vs. DNA+MVA</td>
<td>IAVI</td>
<td>Phase I</td>
</tr>
<tr>
<td>Australia</td>
<td>DNA+fowlpox</td>
<td>US NIH</td>
<td>Phase-I</td>
</tr>
<tr>
<td></td>
<td>DNA+fowlpox</td>
<td>Australia</td>
<td>Phase-I</td>
</tr>
<tr>
<td>China</td>
<td>V3 peptides</td>
<td>UBI Co.</td>
<td>Phase-I</td>
</tr>
<tr>
<td></td>
<td>DNA+MVA</td>
<td>Baike Co.</td>
<td>Phase-I</td>
</tr>
<tr>
<td></td>
<td>Tiantan vaccinia replicative</td>
<td>China CDC/EU</td>
<td>Phase-I</td>
</tr>
<tr>
<td></td>
<td>DNA+ Tiantan replicative</td>
<td>China CDC</td>
<td>Phase-I</td>
</tr>
<tr>
<td></td>
<td>DNA+MVA</td>
<td>Baike Co.</td>
<td>Phase-I</td>
</tr>
<tr>
<td>Thailand</td>
<td>V3 peptides</td>
<td>UBI</td>
<td>Phase-I</td>
</tr>
<tr>
<td></td>
<td>Gp120</td>
<td>Vaxgen</td>
<td>Phase-III</td>
</tr>
<tr>
<td></td>
<td>Gp 160</td>
<td>DoD</td>
<td>Phase-II</td>
</tr>
<tr>
<td></td>
<td>Canarypox+gp160vs.gp120</td>
<td>US NIN/DOD</td>
<td>Phase-II</td>
</tr>
<tr>
<td></td>
<td>Adenovirus type-5</td>
<td>Merck</td>
<td>Phase-II</td>
</tr>
<tr>
<td></td>
<td>MVA</td>
<td>US NIN/DOD</td>
<td>Phase-I</td>
</tr>
<tr>
<td></td>
<td>DNA+fowlpox</td>
<td>Australia</td>
<td>Phase-I</td>
</tr>
<tr>
<td></td>
<td>Canarypox+gp120</td>
<td>US NIN/DOD</td>
<td>Phase-III</td>
</tr>
</tbody>
</table>

Source- CDC, Center for Disease Control and Prevention; DoD, Department of Defense; EU, European Union.

Table no: 2 Contract Manufacturing

<table>
<thead>
<tr>
<th>Indian Company</th>
<th>International Partner</th>
<th>Outsourced Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadila</td>
<td>Altana, Germany</td>
<td>Two intermediates for Altana's under-patent</td>
</tr>
<tr>
<td>Healthcare,Ahemdabad</td>
<td>molecule Protonix (pantoprazole)</td>
<td>Healthcare,Ahemdabad</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Hikal Limited ,Mumbai</td>
<td>Degussa ,Germany</td>
<td>For supplying pharmaceutical intermediates and active pharmaceutical ingredients</td>
</tr>
<tr>
<td>Nicholas Mumbai</td>
<td>Piramal</td>
<td>AMO, Australia</td>
</tr>
<tr>
<td>Nicholas Mumbai</td>
<td>Piramal</td>
<td>Allergan USA</td>
</tr>
<tr>
<td>Nicholas Mumbai</td>
<td>Piramal</td>
<td>Pfizer, New York US</td>
</tr>
<tr>
<td>Dishman Pharma Ahemadabad</td>
<td>Solvay, Brussels - Belgium</td>
<td>6 projects; the main one being for starting material and advanced intermediate for Tevetan (eprosartan maleate)</td>
</tr>
<tr>
<td>Dishman Pharma Ahemadabad</td>
<td>AstraZeneca</td>
<td>Intermediate for Nexium (esomeprazole)</td>
</tr>
<tr>
<td>Dishman Pharma Ahemadabad</td>
<td>Merck, USA</td>
<td>Intermediate for Losartan (to be supplied to its contract manufacturer in Japan)</td>
</tr>
<tr>
<td>Shasun Chemicals Chennai</td>
<td>GlaxoSmithKline, London UK</td>
<td>Ranitidine API</td>
</tr>
<tr>
<td>Shasun Chemicals Chennai</td>
<td>Eli Lilly USA</td>
<td>Nizatidine, metohexital and cycloserine APIs</td>
</tr>
</tbody>
</table>

Source – Company Website

**Table 3: Industry to industry Collaboration in the Indian Generics Pharmaceutical**

<table>
<thead>
<tr>
<th>Indian Generics</th>
<th>Collaborating with industry</th>
<th>Purpose of Collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Reddy’s Laboratories Ltd</td>
<td>Danish Biopharma, Norway</td>
<td>Developing anti-diabetes molecule</td>
</tr>
<tr>
<td></td>
<td>Ceragenix Pharm In Colorado US</td>
<td>Distribute and market EpiCeram, a cream used to treat atopic dermatitis</td>
</tr>
<tr>
<td></td>
<td>GlaxoSmithKline plc (GSK) UK</td>
<td>To develop and market select products across emerging markets outside India.</td>
</tr>
<tr>
<td></td>
<td>Argenta Discovery, UK</td>
<td>For The Joint Development And Commercialization Of A Novel Approach To The Treatment Of Chronic Obstructive Pulmonary Disease (“COPD”)</td>
</tr>
<tr>
<td></td>
<td>SCOLR Pharma, Inc., BELLEVUE, Wash.</td>
<td>Pursue the development and commercialization of an undisclosed oral prescription drug with significant potential</td>
</tr>
<tr>
<td>Company</td>
<td>Country</td>
<td>Activity</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>--------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Symbiotics, New Zealand</td>
<td>New Zealand</td>
<td>Has launched New Life Colostrum. The product is available in a novel chewable form for the first time in India.</td>
</tr>
<tr>
<td><strong>Ranbaxy Laboratories Ltd</strong></td>
<td></td>
<td><strong>GlaxoSmithKline UK</strong></td>
</tr>
<tr>
<td><strong>Knoll pharmaceutical, India</strong></td>
<td>India</td>
<td>To Market a basket of leading Knoll brands in select overseas markets</td>
</tr>
<tr>
<td><strong>Orchid Chemicals &amp; Pharmaceuticals Limited (Orchid)</strong></td>
<td></td>
<td>Formulations and active pharmaceutical ingredients</td>
</tr>
<tr>
<td><strong>BioPro Pharmaceutical, Inc., (BioPro)</strong> USA</td>
<td></td>
<td>To promote and market Gliadel® Wafer in India</td>
</tr>
<tr>
<td><strong>Pfizer Inc New York</strong></td>
<td></td>
<td>To settle most of the patent litigation worldwide involving Atorvastatin (Lipitor), the world’s most-prescribed cholesterol-lowering medicine</td>
</tr>
<tr>
<td><strong>Sirtex Medical Pvt Ltd (Sirtex), Australia</strong></td>
<td></td>
<td>To promote and market Sirtex’s product, SIR-Spheres®.</td>
</tr>
<tr>
<td><strong>GSK Pharma London UK</strong></td>
<td>UK</td>
<td>To provide Ranbaxy expanded drug-development responsibilities and further financial opportunities.</td>
</tr>
<tr>
<td><strong>Zenotech Laboratories Limited (Zenotech), India</strong></td>
<td></td>
<td>Ranbaxy will market Zenotech’s oncology cytotoxic injectible products under the Ranbaxy label</td>
</tr>
<tr>
<td><strong>Mallinckrodt Baker Inc Europe</strong></td>
<td>Europe</td>
<td>Marketing alliance that RFCL will market MBI JT Baker and Mallinckrodt's range of Scientific Laboratory Products in the Indian market.</td>
</tr>
<tr>
<td><strong>CorePharma LLC of Middlesex, New Jersey</strong></td>
<td></td>
<td>To manufacture and market the fixed combination of Dextroamphetamine Saccharate, Amphetamine Aspartate</td>
</tr>
<tr>
<td><strong>Wockhardt Ltd Mumbai</strong></td>
<td>Mumbai</td>
<td>Establishment of a strategic business alliance for the US market.</td>
</tr>
</tbody>
</table>
| **Cipla Ltd Mumbai**                      | Mumbai                         | To co-market Ranbaxy's once-
<table>
<thead>
<tr>
<th>Company Name</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a-day formulation of Ciprofloxacin</strong></td>
<td></td>
</tr>
<tr>
<td>Merck &amp; Co., Inc. USA</td>
<td>To Develop Clinically Validated Anti-Bacterial And Anti-Fungal Drug Candidates</td>
</tr>
<tr>
<td>Schwarz Pharma Germany</td>
<td>For molecule RBx 2258 conducting Phase-I clinical studies on the molecule in Europe</td>
</tr>
<tr>
<td>GSK Pharma plc UK</td>
<td>Drug discovery and clinical development collaboration covering a wide range of therapeutic areas</td>
</tr>
<tr>
<td>J. B. Chemicals &amp; Pharmaceuticals Limited (JBCPL) Mumbai</td>
<td>Marketing of JBCPL’s key herbal range brand, Doktor Mom</td>
</tr>
<tr>
<td>Validus Pharmaceuticals LLC Parsippany, NJ USA</td>
<td>To market and distribute an authorized generic version of Rocaltrol® (calcitriol) in both softgel capsules and an oral liquid formulation</td>
</tr>
<tr>
<td>Daiichi Sankyo Company Limited Tokyo, Japan</td>
<td>Market the osteoporosis medication, Evista® in Romania</td>
</tr>
<tr>
<td>Astrazeneca Pharmaceuticals London UK</td>
<td>Launched an authorized generic of Omeprazole 40 mg Capsules in the U.S. healthcare system</td>
</tr>
<tr>
<td>Cephalon, Inc Frazer, PA</td>
<td>To settle their pending patent infringement dispute in the United States related to PROVIGIL® (modafinil) Tablets</td>
</tr>
<tr>
<td>Avestha Gengraine Technologies Pvt. Ltd Bangalore</td>
<td>To carry out project activity relating to construction of recombinant cell lines required for screening Ranbaxy's drug candidates.</td>
</tr>
<tr>
<td>National Institute of Pharmaceutical Education and Research (NIPER)</td>
<td>Project on “Solubility / Permeability enhancement”</td>
</tr>
<tr>
<td>Company</td>
<td>Collaborator</td>
</tr>
<tr>
<td>-------------------------------</td>
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</tr>
<tr>
<td>Nicholas Piramal</td>
<td>Arkray Inc, Japan-based</td>
</tr>
<tr>
<td></td>
<td>DxTech LLC (“DxTech”),</td>
</tr>
<tr>
<td></td>
<td>Biogen Idec of USA</td>
</tr>
<tr>
<td></td>
<td>Arkray Inc, Japan-based</td>
</tr>
<tr>
<td></td>
<td>Allergen Inc USA</td>
</tr>
<tr>
<td></td>
<td>The Pierre Fabre Group,</td>
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<tr>
<td></td>
<td>Fabre Laboratories</td>
</tr>
<tr>
<td></td>
<td>AstraZeneca AB, Sweden</td>
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<tr>
<td></td>
<td>Sun Pharmaceuticals</td>
</tr>
<tr>
<td>GlaxoSmithKline Pharma</td>
<td>Ranbaxy Laboratories</td>
</tr>
<tr>
<td></td>
<td>Organon</td>
</tr>
<tr>
<td></td>
<td>EISAI Pharmaceuticals India</td>
</tr>
<tr>
<td></td>
<td>Daiichi sankyo</td>
</tr>
<tr>
<td></td>
<td>Japan based Astellas Pharma</td>
</tr>
<tr>
<td></td>
<td>Aurobindo Pharma</td>
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<tr>
<td>Company</td>
<td>Company</td>
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<tr>
<td>Cadila healthcare Ltd</td>
<td>Novavax</td>
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<td></td>
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</tr>
<tr>
<td>Prolong Pharmaceuticals, US</td>
<td></td>
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<tr>
<td>Polish company Polfa Tarchomin</td>
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<tr>
<td>Karo Bio</td>
<td></td>
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<tr>
<td>Eli Lilly</td>
<td></td>
</tr>
<tr>
<td>Wockhardt Ltd</td>
<td>Pharma Dynamics (S. Africa)</td>
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<tr>
<td></td>
<td>Sidmak Laboratories Inc., USA</td>
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<tr>
<td></td>
<td>Ferring AB, Norway</td>
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<tr>
<td>Biopharm Ltd, Europe</td>
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<tr>
<td>Rhein Biopharm Ltd</td>
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<tr>
<td>Ranbaxy Pharmaceuticals Inc</td>
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<tr>
<td>IVAX Pharmaceuticals Ltd</td>
<td></td>
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<tr>
<td>Eisai of Japan</td>
<td></td>
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<tr>
<td>Company</td>
<td>Location</td>
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</tr>
<tr>
<td>Lupin Ltd</td>
<td>Natco, India</td>
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<tr>
<td>DSM Anti-Infectives India Ltd</td>
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<tr>
<td>Cornerstone BioPharma</td>
<td></td>
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<tr>
<td>ASCEND Therapeutics, Inc.</td>
<td></td>
</tr>
<tr>
<td>Bayer Health Care</td>
<td></td>
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<tr>
<td>Ind-Swift Limited</td>
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<tr>
<td>GSK Philippines</td>
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<tr>
<td>Aspen Pharmacare of South Africa</td>
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<tr>
<td>Chester Valley Pharmaceuticals</td>
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<tr>
<td>Forest Laboratories, Inc</td>
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<tr>
<td>Symbiotec Pharmalab Ltd</td>
<td></td>
</tr>
<tr>
<td>Kyowa Pharmaceutical Industry Co. Ltd.,</td>
<td></td>
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<tr>
<td>Laboratoires Servier of France</td>
<td></td>
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<tr>
<td>Allergan, Inc</td>
<td></td>
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<tr>
<td>Natco Pharma</td>
<td></td>
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<tr>
<td>Cipla Ltd</td>
<td>Avesthagen, India</td>
</tr>
<tr>
<td>Company</td>
<td>Products</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Watson Pharmaceuticals, Inc, USA</td>
<td>To develop and commercialise generic pharmaceutical products.</td>
</tr>
<tr>
<td>Ranbaxy laboratories</td>
<td>To co-market Ranbaxy’s once-a-day formulation of Ciprofloxacin</td>
</tr>
<tr>
<td>Indian Institute of Chemical Technology.</td>
<td>Launches etoposide, a breakthrough in cancer chemotherapy, in association with Indian Institute of Chemical Technology.</td>
</tr>
<tr>
<td>Avestha Gengraine Technologies</td>
<td>To develop biopharmaceuticals and a new class of biotech products called targeted therapies. The partnership will develop products for auto-immune disorders and will subsequently be broadened to include other areas such as cardio-vascular disease and cancer.</td>
</tr>
<tr>
<td>LTT Bio-Pharma Co. Ltd</td>
<td>To help cipla develop nanosteroids, which have the potential to be more effective and produce fewer side effects than conventional steroid treatments.</td>
</tr>
<tr>
<td>Ranbaxy Laboratories</td>
<td>To co-market Ranbaxy third new drug delivery system (NDDS) product, Rofibax-gel in the domestic market</td>
</tr>
<tr>
<td>US company Pentech Pharmaceuticals</td>
<td>For a range of generic products for the American market</td>
</tr>
<tr>
<td>US biotechnology firm, Biogenerics</td>
<td>For a marketing and manufacturing alliance. Under the alliance with Biogenerics, Cipla will market certain biogeneric products in India and also make some niche biotechnology products at their plant here</td>
</tr>
<tr>
<td>Company</td>
<td>Activity</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Major Ivax, now Teva</td>
<td>To supply an active pharmaceutical ingredient (API) for a pediatric drug in US market.</td>
</tr>
<tr>
<td>Biocon Ltd</td>
<td>Vaccinex, Inc To discover and co-develop at least four therapeutic antibody products.</td>
</tr>
<tr>
<td>Abraxis BioScience, Inc</td>
<td>To develop a biosimilar version of G-CSF (granulocyte-colony stimulating factor) in North America and the European Union</td>
</tr>
<tr>
<td>Nobex</td>
<td>For the global co-development and commercialization of oral insulin and oral B-type natriuretic peptide (BNP).</td>
</tr>
<tr>
<td>Amylin Pharmaceuticals, California</td>
<td>For A Peptide Hybrid Or Phybrid.To Invigorated Its Diabetics Drug Development</td>
</tr>
<tr>
<td>IATRICA Biotechnology Company, USA</td>
<td>To Develop Novel Immunoconjugate Therapeutics Against Cancer And Infectious Diseases.</td>
</tr>
<tr>
<td>Syngene International and Innate Pharmaceuticals</td>
<td>Collaborate To Develop Virulence Blockers</td>
</tr>
<tr>
<td>Vaccinex, Inc</td>
<td>To Discover And Co-Develop At Least Four Therapeutic Anti-Body Products.</td>
</tr>
<tr>
<td>Nobex Corporation</td>
<td>To Develop An Oral Peptide Product For The Treatment Of Cardiovascular Diseases.</td>
</tr>
<tr>
<td>Clinigene International, A Wholly Owned Subsidiary Of The Company And SCIREX Corporation</td>
<td>To Collaborate On Global Clinical Trials.</td>
</tr>
<tr>
<td>BAYER AG</td>
<td>For co-development of innovative biotech drugs</td>
</tr>
<tr>
<td>NOBEX Pharma US</td>
<td>For product development in the oral insulin program</td>
</tr>
<tr>
<td>Mylan laboratories</td>
<td>To enter the Global Generic Biologics Market</td>
</tr>
<tr>
<td>Bristol-Myers Squibb Company (BMS)</td>
<td>Opening of a fully dedicated research and development facility for Bristol-Myers Squibb in Biocon</td>
</tr>
<tr>
<td>DuPont Crop Protection</td>
<td>To cover a broad range of</td>
</tr>
<tr>
<td>Company</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Neopharma</td>
<td>R&amp;D technical capabilities to support dupont's discovery pipeline.</td>
</tr>
<tr>
<td>SCIREX Corporation</td>
<td>To enter into the rich GCC (Gulf cooperation Council) market of six Arab States. UAE, Bahrain, Kuwait, Saudi Arabia, Oman and Qatar.</td>
</tr>
<tr>
<td>STARDEX Corporation</td>
<td>They have signed a Letter of Intent (LOI) to collaborate on global clinical.</td>
</tr>
<tr>
<td>CIMAB</td>
<td>To license out three experimental cancer drugs to a Californian Biotechnology company, cancervax Corporation.</td>
</tr>
<tr>
<td>STRAND Genomics, the Bangalore based bioinformatics company and Clinigene International, a subsidiary of Biocon India Ltd., have entered into a strategic partnership</td>
<td>To discover new biological wisdom from clinical data which would lead to novel diagnostics and therapies?</td>
</tr>
<tr>
<td>Bayer HealthCare (BHC)</td>
<td>Licensing agreement with multinational healthcare corporation Bayer HealthCare (BHC) for the exclusive marketing and trademark rights for INSUGEN for the Chinese market</td>
</tr>
<tr>
<td>CIMAB</td>
<td>To license out three experimental cancer drugs to a Californian Biotechnology company, Cancer ax Corporation.</td>
</tr>
<tr>
<td>Abraxis BioScience</td>
<td>Commercialization of ABRAXANE in India.</td>
</tr>
<tr>
<td>Orchid Pharma</td>
<td>New drug discovery and development in the USA.</td>
</tr>
<tr>
<td>BEXEL Biotechnology Inc USA</td>
<td>For marketing Orchid's select life-saving injectable antibiotic formulations in identified regulated markets</td>
</tr>
<tr>
<td>Mayne Group Limited (Mayne)</td>
<td></td>
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<tr>
<td>Company</td>
<td>Description</td>
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<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Actavis pharmaceutical</td>
<td>For marketing 9 of Orchid’s cephalosporin generic formulations in Europe, comprising all the EU (European Union) and CEE (Central &amp; Eastern Europe) countries, numbering 37 in total</td>
</tr>
<tr>
<td>Ranbaxy Laboratories</td>
<td>Business alliance. Orchid would manufacture both finished dosage formulations, and active pharmaceutical ingredients (APIs) for marketing by Ranbaxy</td>
</tr>
<tr>
<td>Merck &amp; Co., Inc.</td>
<td>Discovery, Development And Commercialization Of Novel Agents For The Treatment Of Bacterial And Fungal Infections</td>
</tr>
<tr>
<td>Biovitrum Sweden</td>
<td>To Support Its Drug Discovery Activities</td>
</tr>
<tr>
<td>Bexel Pharmaceuticals</td>
<td>For The Clinical Trial Of Its New Anti Diabetic Molecule In Europe</td>
</tr>
<tr>
<td>Par Pharmaceuticals Inc. (Par)</td>
<td>For marketing of its oral cephalosporin formulations in the US generics market.</td>
</tr>
<tr>
<td>Pfizer International, LLC.</td>
<td>Long-term Master Research &amp; Development agreement</td>
</tr>
<tr>
<td>Merck &amp; Co., Inc.</td>
<td>Discovery, development and commercialization of novel agents for the treatment of bacterial and fungal infections</td>
</tr>
<tr>
<td>Alpharma Inc.</td>
<td>To market its select non-antibiotic generic formulations in the U.S. and Europe.</td>
</tr>
<tr>
<td>Schering-Plough</td>
<td>For patent litigation related to Desloratadine Tablets</td>
</tr>
<tr>
<td>STADA Pharmaceuticals Inc (STADA)</td>
<td>For the development and supply of six prescription generic drug products for the US market.</td>
</tr>
<tr>
<td>Apotex Corp</td>
<td>Marketing tie-ups with Apotex Corp for its sterile cephalosporin formulations to tap the US market.</td>
</tr>
<tr>
<td>North China Pharmaceutical</td>
<td>For manufacturing injectable</td>
</tr>
<tr>
<td>Company</td>
<td>Location</td>
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<tr>
<td>----------------------------------------------</td>
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</tr>
<tr>
<td>MNC in north America</td>
<td></td>
</tr>
<tr>
<td>Merck &amp; Co</td>
<td></td>
</tr>
<tr>
<td>Glenmarck Pharmaceutical</td>
<td></td>
</tr>
<tr>
<td>Dyax Corp, Cambridge</td>
<td></td>
</tr>
<tr>
<td>Merck Kgaa Germany</td>
<td></td>
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<tr>
<td>Forest Laboratories, Inc</td>
<td></td>
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<tr>
<td>Eli Lilly US</td>
<td></td>
</tr>
<tr>
<td>Shasun Chemicals and Drugs Ltd</td>
<td></td>
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<tr>
<td>Invagen Pharmaceuticals, Inc. [invagen] Island</td>
<td></td>
</tr>
<tr>
<td>Teijin Pharma Limited</td>
<td></td>
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<tr>
<td>Indian Generics</td>
<td>Multinationals (MNCs)</td>
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<tr>
<td>Emcure Pharmaceutical Ltd, India</td>
<td>Tibotec, BMS, Gilead</td>
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<td></td>
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<tr>
<td>Aurobindo Pharma, India</td>
<td>BMS, BI</td>
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<tr>
<td>Hetero Drugs Ltd.</td>
<td>Gilead, BI</td>
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<tr>
<td>Strides Arcolab Ltd</td>
<td>Gilead, BI</td>
</tr>
<tr>
<td>Alkem Laboratories</td>
<td>Gilead</td>
</tr>
<tr>
<td>JB Chemicals &amp; Pharmaceuticals</td>
<td>Gilead</td>
</tr>
<tr>
<td>Matrix</td>
<td>Gilead, BI</td>
</tr>
<tr>
<td>Medchem International</td>
<td>Gilead</td>
</tr>
<tr>
<td>Ranbaxy</td>
<td>Gilead, BI</td>
</tr>
<tr>
<td>Shasun Drugs &amp; Pharmaceuticals</td>
<td>Gilead</td>
</tr>
<tr>
<td>Cipla</td>
<td>Merck, BI</td>
</tr>
<tr>
<td>Arcolab,</td>
<td>Merck, BI</td>
</tr>
</tbody>
</table>

Source: Company website

Table: 4 Collaborations of Indian Generic Pharmaceuticals with MNC’s for HIV/AIDS

and COPD For the Territory of Japan

Napo pharma Crofelemer anti-diarrhoeal compound

Forest Laboratories To conduct clinical trials on Oglemilast (GRC 3886), a specific PDE-4 inhibitor, for asthma and chronic pulmonary obstructive disorder.

Sanofi-Aventis To grant Sanofi-Aventis a license for the development and commercialization of novel agents to treat chronic pain.
Table: 5 Some Ongoing Trials of Preventive HIV/AIDS Vaccines Worldwide (September 2010)

<table>
<thead>
<tr>
<th>Protocol #</th>
<th>Start Date</th>
<th>Sponsor, Funder, Developer</th>
<th>Trial Site(s)</th>
<th>Number of Participants</th>
<th>Vaccine(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PHASE II</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HVTN 205</td>
<td>Jan-09</td>
<td>GeoVax, HVTN</td>
<td>US, Peru</td>
<td>225</td>
<td>Prime: DNA vaccine containing gag, pol, env, rat, rev, vpu; Boost: MVA vaccine containing gag, pol, env</td>
</tr>
<tr>
<td>HVTN 505</td>
<td>Jul-09</td>
<td>NIAID, HVTN</td>
<td>US</td>
<td>1,350</td>
<td>VRC-HIVDNA016-00-VP; VRC-HIVADV014-00-VP; Prime: VRC-HIVDNA016-00-VP</td>
</tr>
<tr>
<td><strong>PHASE I / II</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HVTN 078</td>
<td>Oct-09</td>
<td>NIAID, EuroVacc, HVTN</td>
<td>Switzerland</td>
<td>80</td>
<td>NYVAC-B; VRC-HIVADV038-00-VP</td>
</tr>
<tr>
<td>NCHECR-AE1</td>
<td>Jul-07</td>
<td>NCHECR, University of New South Wales,</td>
<td>Thailand</td>
<td>8</td>
<td>A candidate prophylactic DNA prime-rFPV boost HIV vaccination strategy (rFPV-HIV-AE; pHIS-HIV-AE)</td>
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<tr>
<td>HIVIS 03</td>
<td>Dec-06</td>
<td>MUCHS, Karolinska Institute, SMI, Vecura, Tanzania</td>
<td>60</td>
<td>Prime: HIVIS DNA with env, gag, rev, RT</td>
<td>Boost: MVA-CMDR with env, gag, pol</td>
</tr>
<tr>
<td>PHASE I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HVTN 082</td>
<td>Jan-10</td>
<td>NIAID, HVTN US</td>
<td>VRC-HIVDNA016-00-VP; VRC-HIVADV014-00-VP</td>
<td></td>
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<tr>
<td>PedVacc001 &amp; PedVacc002</td>
<td></td>
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</tr>
<tr>
<td>B001</td>
<td>Mar-09</td>
<td>IAVI, University of Rochester Medical Center US</td>
<td>42</td>
<td>Adenovirus serotype 35 vector. Ad35-GRIN/ENV consists of two vectors: Ad35-GRIN vector with gag, reverse transcriptase, integrase, and nef Ad35-ENV vector with gp140 env</td>
<td></td>
</tr>
<tr>
<td>HIVIS 05</td>
<td>Mar-09</td>
<td>Swedish Institute for Infectious disease Sweden</td>
<td>24</td>
<td>MVA-CMDR</td>
<td></td>
</tr>
<tr>
<td>P001</td>
<td>Mar-09</td>
<td>IAVI, Indian Council of Medical Research, Tuberculosis Research Centre, Chennai; National AIDS Research Institute, Pune India</td>
<td>32</td>
<td>Prime: ADVAX (DNA vaccine containing env, gag, pol, nef and tat) Boost: TBC-M4 (MVA vector with env, gag, RT, rev, tat and nef)</td>
<td></td>
</tr>
<tr>
<td>Tiantian vaccinia HIV</td>
<td>Mar-09</td>
<td>Chinese Center for Disease Control and Prevention, National Vaccine and Serum Institute, Peking Union Medical College China</td>
<td>80</td>
<td>HIV-1 CN54 gag, pol and env genes with DNA and rTV vectors</td>
<td></td>
</tr>
<tr>
<td>Vaccine</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ad5HVR48.E NVA.01</td>
<td>Feb-09</td>
<td>NIAID, Brigham and Women’s Hospital US</td>
<td>48</td>
<td>Recombinant Adenovirus HIV-1 Vaccine, Ad5HVR48.ENVA.01</td>
<td></td>
</tr>
<tr>
<td>HVTN 073</td>
<td>Dec-08</td>
<td>HVTN, SAAVI, Brigham and US, South Africa</td>
<td>48</td>
<td>Prime: SAAVI DNA-C2</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Group</td>
<td>Institution and Location</td>
<td>Population and Vaccination Details</td>
<td></td>
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<td>------------------------------------------------------------------------------------------------------</td>
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<td></td>
</tr>
<tr>
<td>Women's</td>
<td>Hospital CRS, Fenway Community Health,</td>
<td>Boost: SAAVI MVA-C; DNA plasmid vaccine with gag, RT, tat, nef, env</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clinical Research Boston, Crossroads, Chris</td>
<td></td>
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<tr>
<td></td>
<td>Hani Baragwanath Hospital</td>
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<tr>
<td>VRC 015 (08-1-0171)</td>
<td>NIAID, VRC, NIH Clinical Center</td>
<td>US</td>
<td>40</td>
<td>Multiclade Recombinant HIV-1 Adenoviral Vector Vaccine, VRC-HIVADV014-00-VP</td>
<td></td>
</tr>
<tr>
<td>Ad26.ENVA.01</td>
<td>NIAID, IPCAVD, Brigham and Women’s Hospital, Beth Israel Deaconess Medical Center, Crucell Center, Crucell</td>
<td>US</td>
<td>48</td>
<td>Recombinant adenovirus serotype 26 (rAd26) vaccine</td>
<td></td>
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<td>Recombinant Adenoviral Subtype 35 (rAd35) and Subtype 5 (rAd5) HIV-1 Vaccines When Given as a Heterologous Prime-Boost Regimen or as Boosts to a Recombinant DNA Vaccine in Healthy, Ad5-Naïve and Ad5-Exposed (VRC-HIVDNA044-00-VP;VRC-HIVADV027-00-VP;VRC-HIVADV038-00-VP)</td>
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**Notes:**

- **Env** DNA vaccine:
  - May-05: St. Jude’s Children’s Research Hospital, US
  - RV 156A: NIAID, HVTN, VRC, MHRP, Makerere U., Uganda

**Additional Information:**

- **ABL:** Advanced BioScience Laboratories
- **ADARC:** Aaron Diamond AIDS Research Center
- **ANRS:** Agence Nationale de Recherches sur le Sida (France)
- **DAIDS:** Division of AIDS
- **HVTN:** HIV Vaccine Trials Network
- **IAVI:** International AIDS Vaccine Initiative
- **MoPH:** Ministry of Public Health
- **NIAID:** National Institute of Allergy and Infectious Diseases
- **NIH:** National Institutes of Health
- **ANRS:** Agence Nationale de Recherches sur le Sida (France)
- **SAAVI:** South African AIDS Vaccine Initiative
- **SGUL:** St. George’s, University of London
- **SMI:** Swedish Institute for Infectious Disease Control
- **UK MRC:** United Kingdom Medical Research Council
- **MHRP:** United States Military HIV

**Legend:**

- **HVRF** with polyoxidonium adjuvant
- **VICHREPOL** with polyoxidonium adjuvant
- **Sanofi Pasteur Live Recombinant ALVAC-HIV (vCP205, HIV-1)**
- **Recombinant HIV-1 multi-envelope DNA plasmid vaccine with env**
- **Recombinant HIV-1 multi-envelope DNA plasmid vaccine with env**
- **VRC-HIVADV014-00-VP alone or as a boost to VRC-HIVDNA009-00-VP**
- **Env/Gag/Pol** subcutaneously, intradermally, or intramuscularly
<table>
<thead>
<tr>
<th>Research Program</th>
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<tbody>
<tr>
<td>MUCHS: Muhimbili University College of Health Sciences</td>
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<tr>
<td>National Centre in HIV Epidemiology and Clinical Research (NCHECR)</td>
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<td>VRC: Vaccine Research Center</td>
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**Source**-Global advocacy for HIV prevention
Reproductive Health Concerns: Impact of Environmental Toxicants on Reproductive Health of Men/Women

Prof. Rita Singh,
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University of Delhi, Delhi

The increased technological advancement has left behind a pool of environmental toxicants affecting our health adversely. In humans, exposure to them may cause cancer, reproductive and developmental disorders. A major concern is the potential effects of the environmental toxicants on reproductive health because of important consequences this may have lifelong and even intergenerational. Unfortunately, the toxicity of most of these is unknown or incompletely studied. Previously, it was believed that the low-level exposure to chemicals in everyday life did not pose a risk to fertility, reproduction, or development. However, a significant body of recent scientific literature suggested that relatively low dose exposure to certain chemicals may also cause harmful effects to health (i.e., subclinical toxicity). There are time lags between health outcomes and exposure to an environmental toxicant and the time when regulatory action is taken or clear guidance provided. Moreover, animal tests often fail to examine for subtle, delayed, or difficult-to-diagnose conditions. We believe that Laws should take a precautionary approach, should guide risk management and regulatory decisions.

The global industrialization and increase in the demand supply cycle has put enormous amount of toxic load on the environment. The technological advancement and violation of the safety norms has left behind a pool of environmental toxicants, adversely affecting our health and the biodiversity. These toxicants are industrial compounds, plastics and plasticizers, fungicides, pesticides, heavy metals present in water, food, air and soil, and others used in everyday products— including detergents, flame retardants, food additives, toys, and cosmetics. Introduction of these hazardous chemicals into the environment has raised a great amount of public concern, primarily because of their adverse effects in human, domestic animals and the wildlife (1). Unfortunately, the toxicological information on most of the environmental toxicants is often incomplete.

Previously, it was believed that the low-level exposure to chemicals in everyday life did not pose a risk to fertility, reproduction, or development. However, a significant body of recent scientific literature suggested that relatively low dose exposure to certain chemicals may also cause harmful effects to health (i.e., subclinical toxicity). Therefore, the underlying premise is that there exists a continuum of toxicity, in which clinically apparent effects have their asymptomatic, subclinical counterparts. Interactive harmful effects of more than one chemical in the environment are not clear as animal testing usually looks at health effects using one chemical at a time. Moreover, animal tests often fail to examine for subtle, delayed, or difficult-to-diagnose conditions. Epidemiological (human) studies are often limited by inaccurate exposure assessments and incomplete information about health outcomes. The toxicity of most synthetic chemicals and metals currently in commercial use is still unknown or incompletely studied. The potential adverse effects of environmental toxicants on the reproductive health of women leading to developmental disorders in children are of major concern. Exposure to some may also cause cancer e.g., organochlorines and certain pesticides are linked to high incidence of prostate cancer.
The most commonly studied environmental toxicants can be divided into three major categories: heavy metals, air pollutants and pesticides. The toxicity caused by these environmental toxicants has a direct link with the duration and the frequency of exposure. The time between multiple exposures also plays a crucial role. Exposure and absorbance of environmental toxicants can happen through skin (dermal), lung (inhalation) and oral (gut).

Over the past few decades, there has been increased number of reports on the toxic effects of certain chemicals and metals in the environment on reproductive health. Women exposed to the environmental toxicants may have menstrual cycle irregularities, spontaneous abortion, infertility (2), endometriosis, auto-immune disorders and cancers of the reproductive system. Types of adverse developmental outcomes associated with exposure to toxins include: still birth/infant death, preterm birth, congenital anomalies (3), low birth weight (4), developmental delays (5), and childhood cancers (6). It has been theorized that this phenomenon is related to increasing levels of environmental exposure to antiandrogenic, estrogenic, or antiestrogenic chemical exposure during critical phases of development (7).

**Reproductive health and transgenerational effects**

The toxic effects on women reproductive health are of concern because of the important consequences that may have lifelong and the intergenerational effects. The emerging data on the effects of toxicants on animals has demonstrated that there are time lags between health outcomes and exposure to an environmental toxicant and the time when regulatory action is taken or clear guidance provided. In the recent years, various environmental threats to public health have surfaced in various parts of the world but are waiting for collection of data. Dr. Shaha's survey (8) in the West Bengal indicated that the lag time for the appearance of arsenic disease is two to five years and according to Allen Smith (9) and others it is about 10 years. In the absence of discrete proof of the toxicity thousands of lives are affected. There are other reports of the outcome of the toxic effects of insecticides and pesticides around various locations globally as well as in India like Kerala, Kanpur, Punjab and Maharashtra (10-11). However, serious steps have not been implemented to prevent and mitigate the ill effects on human health well before they are visible. The transgenerational effects of vinclozolin and polychlorinated biphenyls (PCBs) have been reported (12). Interestingly, the transgenerational inheritance of non-genomic information has also been reported (12). The study showed that male F3 descendants from the vinclozolin lineage were significantly less attractive to a female mate than those from the vehicle lineage. Prenatal exposure to Aroclor 1221 (PCB) resulted in perturbed reproductive hormones in F2 generation.

**Endocrine disruption by environmental toxicants**

The adverse effects of environmental toxicants on reproductive and developmental processes are due to their endocrine disrupting activity brought about by targeting the neuro-endocrine systems. Neuroendocrine cells (neurons) respond very rapidly (in the order of, milliseconds to seconds) to external stimuli like environmental signals and are perfectly poised to mediate responses to environmental stimuli. Thus, the neuro-endocrine mechanisms are highly vulnerable to disruption by environmental contaminants such as, industrial chemicals, pesticides, plastics/plasticizers, as well as food products. These endocrine disrupting chemicals (EDCs) affect the homeostatic processes in the body, including reproduction, growth, metabolism and energy balance, and stress responses. These chemicals may be present in the diet and being lipophilic, can pass across the food chain, accumulated in fat and thus, can result in biomagnifications. The diverse structures and properties of EDCs cause adverse effects on reproductive tissues e.g. binding to nuclear hormone receptors to stimulate or antagonize them; interference with enzymes involved in steroid biosynthesis; neurotransmitter systems
that are steroid sensitive; hormone degradation/elimination but the net effect on an organism is an altered endocrine phenotype. The exposure of developing fetus, growing children and adolescents to “environmental endocrine disruptors” or EDCs may harm the maturation of the neuro-endocrine feedback mechanisms (Fig.1) leading to endocrine disorders in adulthood (13). Estrogen receptors can bind EDCs, including PCBs, phytoestrogens, pesticides, compounds in plastics such as bisphenol A (BPA), and other chemicals (14-16). Dioxins and some PCBs are potent agonists to the aryl hydrocarbon receptor (AhR) (17), which is abundantly expressed in the brain (18). PCBs can cause activation or suppression of thyroid hormone receptor activity depending upon the specific PCB mixture or dose. Phthalates are androgen receptor antagonists, and vinclozolin, a fungicide, acts, at least in part, as an anti-androgen. PCBs have been shown to bind to serotonin, dopamine, and noradrenergic receptors (19) therefore; they interfere with these neurotransmitters which act upon the hypothalamic releasing factors that control the pituitary gland, the producer of trophic hormones (Fig.1).

**Figure 1:** The Neuroendocrine system, Feed-back mechanism and regulation of homeostasis in the human body (source: Internet, modified picture). Red arrows show the locations where environmental toxicants or endocrine disrupting chemicals can affect the Neuroendocrine system directly.

Exposures to heavy metals like lead and mercury are reported to be associated with spontaneous abortions in female workers. A study conducted at University of Florida, US, revealed that mercury contamination in the river is converting the male American white ibises birds’ homosexual, resulting in reduced breeding (20). These birds get exposed to methyl mercury by feeding on crustaceans and small invertebrates and absorb the toxic chemicals from the municipal waste disposed nearby the river. Benzene present in inks, glues, gasoline and paint remover can cause damaging effects on the developing reproductive system. Several specific solvents have been known to have additional adverse effects like glycol ethers which damage male reproductive function. Present in the household related products are toluene and naphthalene which have toxic effects on
reproductive physiology. It has also been reported that the farmers exposed to mixtures of pesticides are at increased risk of spontaneous abortion and birth defects in offspring. BPA, a controversial plastic ingredient (chemical) which is used primarily in the production of polycarbonate plastics and epoxy resins, affects fertility. It is found in items such as: plastic bottles, food storage containers, compact discs, and water supply pipes. People, including children, are exposed to BPA when it leaches from the coatings of canned foods and from plastic products. The highest estimated daily intakes of BPA have been seen in infants and children. The European Union (EU) has banned BPA in plastic baby bottles, as this chemical could affect the development and the immune response in children. This ban will come into effect from the year 2011. Denmark and Canada have already tagged the chemical toxic.

The 2002 National Survey of Family Growth found that approximately 7.5% of men sought help for infertility, some time during their lifetime (3.3-4.7 million men) (21-22). From men who sought help, 18.1% were diagnosed with a male-related infertility problem, including sperm or semen problems (23). Selevan et al. (24) provided evidence that exposure to episodes of air pollution may have adverse effects on semen quality, specifically on sperm chromatin integrity. Rubes et al. (25) demonstrated that exposure to intermittent air pollution may result in sperm DNA damage and thereby increasing the rates of male infertility, miscarriage, and other adverse reproductive outcomes. During 1970s, use of an agricultural fumigant 1, 2-dibromo-3-chloropropane [dibromochloropropane / DBCP] in the US, demonstrated to cause sterility in males working in a chemical plant. New research from the Harvard School of Public Health showed that men who consume a high amount of soy-based food products have lower total sperm counts (26). This adverse effect of soy is because it is rich in estrogenic compounds known as isoflavones including genistein, daidzein, and glycitein.

**Controlling environment: Global policy pitfalls and potentials**

In late 1950s, the pesticide use in US caused toxic effects on human as well as fauna and flora. There were no regulations until 1962 when Rachel Carson published a book named “Silent Spring”, which described the toxic effects of DDT and other pesticides on human life. Impact of this book was such that President Kennedy set up a special panel of his science advisory committee, to study the problem of pesticides and environmental pollutants. Thereafter, a number of relevant legislations and regulations regarding the exposure to environmental hazards were brought into shape for the maintenance of unpolluted water, air and food. Collegium Ramazzini (27) declared an international ban on all uses of asbestos, as it was a known carcinogen, moreover; International Commission for Occupational Health (ICOH) joined this ban. From then, many countries have restricted and some even banned (Belize, Denmark, Germany, Netherlands, Singapore and Sweden) the use of some of the highly toxic pesticides or insecticides like DDT, asbestos and endosulfan (suspected endocrine disruptor) (Fig. 2)
Some countries like, Britain, Canada, Finland, Kuwait, the Philippines, Russia, Sri Lanka, Thailand, and Madagascar, severely restricted the use of endosulfan. Furthermore, Bangladesh, Indonesia, South Korea, and Thailand banned endosulfan in the rice fields. Despite heavy pressure from industry different countries like Philippines, Benin and Colombia have tried to ban this pesticide. They have supported the ban at the sixth meeting of Persistent Organic pollutants Review Committee to the Stockholm Convention. However, India is still to join combat against endosulfan which has left many children crippled in Padre village (Fig. 3), and other toxic pesticides and insecticides which have suspected endocrine disruptor activity.

![Figure 2: Summary of the toxicity information available for endosulfan](image1)

![Figure 3: Health hazards of endosulfan use in Padre Village, Kasargod district, Kerala, India](image2)

**The hazardous wastes management and handling in India**

Figure 4: Data requirements for registration of chemical pesticides for home consumption / export


With reference to the requirements listed by Central Insecticides Board and Registration Committee (CIBRC), India for the registration of the chemical pesticides/Insecticides (Fig. 4, www.cibrc.nic.in), the effect on reproduction, carcinogenicity and effect on metabolism are ignored even for new formulations. The Rules 2008 give a categorization for handling the toxic chemical wastes for recycling. This will open the floodgates for import of recyclable hazardous waste to India, making it a global waste destination. This rule also reduces the control over the generators and handlers of hazardous waste. These steps, in fact, seem to be more favorable towards making India a ‘dumping destination’ in the garb of ‘recycling destination’. Some of other major drawbacks in the rules 2008 are: It describes certain characteristics by which the waste can be termed hazardous where characteristics like leachiability have not been included. The definition of disposal covers only land disposal- missing out on disposal in other mediums. It does not mandate permission from transit countries, in case of export-import- this is in complete violation of the Basel Convention. It does not propose streamlined collection mechanism for hazardous waste, especially new wastes like E-waste. It does not address the inadequacy of disposal sites. Occupational health safety measures in the units handling hazardous waste have also not been dealt with. No incentive or move is discussed to phase out the toxic products. The regulation does not mention the proper handling and disposal of hazardous waste at first place, which is far from reality.

Global trade

Global trade of hazardous materials such as pesticides, asbestos and toxic waste like E-waste, CFL lamps, are still not well regulated in most parts of the world except for EU. Therefore, health hazards follow the toxic trade routes which invariably terminate into developing nations. Industry externalizes health and environmental costs by utilizing least expensive materials, even if they are
hazardous to human health. Such industries should be moved to regulated sites of production and must trade with regulated markets. However, there is unequal risk to the developing world. The export of toxic chemicals and hazardous processes from the industrially developed to the developing nations of the world has the potential to profoundly change patterns of morbidity and mortality, especially in children. Examples of the spread of toxic chemicals are carbide gas in Bhopal, asbestos export, export of “banned” pesticides, arsenic in Bangladesh, pesticides in central Asia and export of hazardous waste.

It has been reported that US exports up to 80% of E-waste to developing nations and China receives 70% of the world's scrap electronics product. Canada produces 200,000 tons of asbestos annually 97% of which is exported to the developing world. The production of asbestos has increased over the years though it is a known carcinogen. Only 20% of world pesticide market is in the developing world but 99% of pesticide-related deaths are reported from the developing countries basically because of the unregulated dumping of banned or restricted pesticides. Subject to some requirements, the general practice is that pesticides that are not approved - or registered - for use in the country but are manufactured in the country are exported to other countries (29).

Pesticides which may not be in use in US but are exported to other countries do not require registration in US (30). US-EPA pesticide policy comes with the justification that unilateral prohibition was not sufficient and it is required that we focus on safe use of all pesticides and this is precisely based on risk/benefit analysis in US. In 1997-2000, US exported 65 million pounds of banned or severely restricted pesticides (>57% shipped to developing world), 16 tons/day never-registered chemicals, 89 million pounds extremely hazardous pesticides. The EPA pesticide policy ignored the importance of US exports and the reality of pesticide use in developing world. Therefore, “safe use” is difficult to implement in view of no effective local regulation and testing. The global EPA has to come into existence and modify the regulation on toxic trade. These occupational and environmental exposures in the developing world would result in food exposures in developed world starting a “Circle of Poison”. Therefore, it is mandatory to avoid global trade of toxic substances and increase the linked global awareness.

**Global conventions**

Various global conventions are held to limit the use and disposal of toxic and hazardous waste / chemicals like Basel Convention on movement of hazardous waste, Stockholm Convention on Persistent Organic Pollutants (POPs), Rotterdam Convention on Prior Informed Consent (PIC) and European Union Regulations. The basic objectives of the Basel Convention are: control and reduce the transboundary movements of hazardous and other wastes, prevention and minimization of their generation, environmentally sound management of such wastes and active promotion of the transfer and use of cleaner technologies. Only Basel tries to address waste trade from a comprehensive perspective whereas, PIC and POPs mainly address particular chemicals, necessitating constant review. European Union Regulations are the cutting edge of environmental regulation in Europe. These are as follows:

**RoHS** (Restriction of Hazardous Substances in Electrical and Electronic Equipment): Restricts the use of only 4 heavy metals and 2 flame retardants. It is pushing worldwide compliance for affected industries. In China, Draft Pollution Control and Prevention Regulation adopted RoHS elements. In California, State recycling regulation adopted RoHS elements. Electronic Waste Recycling Act of 2003 contains a provision that prohibits a covered electronics device from being sold or offered for sale in California, if the device is prohibited from being sold in the European Union by the **RoHS Directive** (31).
**WEEE (Waste Electrical and Electronic Equipment):** Producers must collect and recycle EEE at end of product life.

**REACH (Registration, Evaluation, Authorization and Restriction of Chemical substances):** Improves chemical health and safety regulations and shifts responsibility to industry to provide safety information and manage risks from chemicals; adopts the precautionary principle. REACH applies to imported and exported chemicals but it exempts chemicals “in transit”.

**Policy options for India**

India is equipped with a solid brigade of legal provisions and policy documents designed to protect and improve the natural environment. Article 48(a) of Constitution of India directs the State to take strong measures not only for its protection but also work actively for its improvement. Article 51(a) enforces a corresponding duty on the citizen to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures. We have an Air (Prevention and Control of Pollution) Act and a similar Water Act. We have an EPA of 1986 amended from time to time to control hazardous pollutants. Each one of our nine five year plans contains a chapter on safeguarding the environment. We have Forest Acts stretching from 1861 to 1988. We have state and central boards for the prevention of pollution. Our Judiciary has been exceptionally active in allowing public interest litigations that resulted in the State taking measures for its improvement or refraining from taking measures that would degenerate our ecology. We have the Prevention of Food Adulteration (PFA) Act 1954 promulgated by the Parliament in 1954 to make provision for the prevention of adulteration of food. Broadly, the PFA Act covers food standards, general procedures for sampling, analysis of food, powers of authorized officers, nature of penalties and other parameters related to food. The provisions of PFA Act and Rules are implemented by state government and local bodies as provided in the rules. It deals with parameters relating to food additives, preservative, coloring matters, packing & labeling of foods, prohibition & regulations of sales etc. However, the core issues affecting or rather controlling India's natural environment have remained the same.

What can we do from here? Firstly we have to organize a common forum for assessment of policies for each kind of environmental toxicants which are leaching into our habitat at home without being near to a waste disposal site or an industrial unit. In other words, the environmental toxicants have reached us through the routes which we thought were safe. We have understood that the subclinical effects of the low levels of environmental toxicants over a period of time can cause the disease like cancer. We have to build new policies and also use EU policies within country and globally to advocate for higher international health and safety standards. We can adopt EU policies at local and state level and work with EU and global allies to expand the scope of coverage of EU regulations. It would be wise to use EU policy ideals to organize for better regulation at home. Ultimately world requires a global regulatory body that can regulate and coordinate the minimal use of toxic chemicals by phasing them out by replacement with non-toxic alternatives. Policies need to be developed to further link regulations to international trade. Public opinion and political commitment has to be favorable in this regard and that can further integrate EU standards into international standard-setting processes. Expanding REACH to chemicals in transit would further be precautionary. Requiring companies to adopt REACH, ROHS, etc. in global operations could make industry push for similar regulations in trade agreements to flatten competition from companies not doing business in EU. Individual nations may institute stronger (or weaker) regulations and globalize protection instead of hazards. The enforcement of laws/ regulations would be unclear and ineffective until the number of nation signatories is significant.
Precautionary measures for protection from environmental toxicants

The following steps can be taken so as to minimize the exposure of human, animal and wildlife to environmental toxicants:

1. Protective Risk Assessment.

Where there is some evidence of human or environmental toxicity, the precautionary approach demands that exposures be avoided or minimized.

2. Protective Regulation.

We believe that laws should take a precautionary approach, should guide risk management and regulatory decisions. This means that the issue of safety should be thoroughly considered before human and environmental exposures are permitted. No hazardous substance should be allowed to reach inhabited areas because of lack of information, time, or funding.

3. Right-to-Know Legislation.

Multiple sites where commonly used commercial and industrial solvents migrate into the groundwater from soil contamination highlight the need for early notification to nearby private well owners. So individuals can test their water and make important decisions that may impact their families’ health. An efficient example of environment protection under the right to know legislation is the working of the Illinois Environmental Protection Agency (Illinois EPA or Agency). Illinois EPA has become aware of contamination in the environment in certain areas of the State that threatens the safety of drinking water supplies from groundwater sources. The law may be found in the EPA at 415 ILCS 5/25d – 25d-10 (P.A. 94-314). The law mandates that the Illinois EPA gives timely notification to Illinois citizens about contamination in soil or groundwater that may threaten public health. A similar example can be cited for the panchayat of Chengalam, Kottayam district, Kerala where the local people are notified about quality of drinking water in the panchayat well.

4. Environmental Reproductive Health Research.

The regulation 2008 defines the wastes as toxic if these are either contaminated or containing established carcinogens, mutagens or endocrine disruptors. Therefore, increased research efforts are required to establish the potential carcinogens, mutagens or endocrine disruptors in the environment whether these are in food, water or air. The materials in normal use or waste materials expected to contain EDCs should be banned from import for recycling. Proper detection procedures are required to establish the presence of EDCs in food packing materials, containers, food additives or wastes generated within country by the concerned engineering research programs. Most of the chemicals to which children are exposed have not been properly tested for toxicity. This is urgently required precisely because children have diminished ability to detoxify and excrete many chemical toxins and they have a heightened biological vulnerability, e.g., to thalidomide, diethylstilbestrol (DES). The toxic effect may appear because they have more years of future life. There has been increase in the young cases of asthma and cancer in US. Developmental disabilities affect 3-8% of all children in US. Such data are required to be collected in India to establish the potential hazardous chemicals in the environment.

A new direction in research would be to have multi-year prospective epidemiological study to examine the influence of children’s early life exposures to environmental toxins and explore simultaneous impact of many risk factors on the long term health of children. Contribution of indoor and ambient air pollution to the origins of asthma is a required area of research due to the increased incidence of asthma in children. Environmental causes of developmental disabilities and cancers in
children may be due to the effects of endocrine disruption by steroidogenic effects during the gestation period.

5. Training Programs: Health Workers, Farmers and School Teachers.

Reproductive health providers mainly doctors must play a significant role in communicating environmental health risks, as they are the key and trusted source of health information, for women, during the preconception. Integrating information on environmental health into medical education curriculum would keep the clinician well informed about the toxic environment around them.

Appropriate information on the use of fertilizers must be known to farmers so that they do not use excessive amounts of chemical fertilizers and toxic insecticides. An important issue about the unknown but possibly increased toxicity of fake and cheap fertilizers, pesticides and insecticides should also be known to the farmers. They should also know how these kinds of practices can contaminate the underground water in the area and that can worsen the toxic effects on human life in a long run.

The vulnerability of children to environmental toxicants is well recognized by World Health Organization (WHO), the United Nations’ Children’s Funds (UNICEF) and its environmental program (UNEP). Persistent bioaccumulative toxins represent a real and urgent threat to children’s environmental health and our obligations to intergenerational equity (32-33). There is an urgent need for precautionary responses from government, industry and the community. In this regard, various community workers, school teachers and representatives from industry must involve themselves in the training programs, to educate children about the toxic threats and the protective measures, to avoid exposure to toxic chemicals in soil, water, air and food.


Presume that the women and children are more vulnerable to environmental toxicants even in the absence of evidence to the contrary. Women and children must be educated about the impact of chemical toxicants on reproductive health. If the source of drinking water is a private well, documentation of water quality should be sought because private wells are not regulated for water quality by the EPA in India. The use of containers that have the symbol #7 on the bottom should be stopped by substituting glass because some of these are polycarbonate and might contain BPA. The use of PVC or vinyl containing plastics (symbol #3) as food or beverage containers must be eliminated, particularly when microwaving and must be replaced by safe alternatives like, glass or polyethylene plastic (symbol #1). Plastics should not be kept in the dishwasher. Promote the use of baby products with labels that say they don't contain phthalates.

7. International Program in Environmental Health

We need to develop an overall research agenda for addressing various new age environmental issues. The toxicity of the compounds should be checked at the doses, which are encountered in contaminated areas such that the observations become relevant for human exposure. Transgeneration effects of low dose would have more relevance in the context of human exposure. A combination of compounds naturally contaminating human environment should be checked instead of single compounds as cumulative effect of low doses of different compounds can lead to higher toxic effects. Studying exaggerated doses or concentrations in vitro will not answer any questions as excess of even useful drugs can be toxic depending on the dose given to a patient.

In conclusion, there are uncertainties to the evaluations & characterizations of health risks from environmental toxicants present in low levels. We need to improve monitoring of changes potentially
relevant to public health resulting from environmental policies. The precautionary measures should be taken even if some cause-and-effect relationships are not fully scientifically established. We will have to share our knowledge and experience with governments, civil society, the private sector, and the whole international scientist community to renew our commitment to reproductive health of men/women and children by advancing a new vision in which every person has a healthy life and a clean environment. Hope things get better in real time and give the operational model, a pragmatic and profitable exposure, which is the need of the hour.

References


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29. FIFRA Section 17 (a) http://www.epa.gov/oppfead1/international/trade-issues.htm.


Unlike biomedical research, health research has a broader canvas and involves a large number of partners located in various sectors viz. public, private, non-governmental, inter-governmental, philanthropic as well as bilateral and multilateral agencies. In government various ministries and the departments therein contribute to improvement of health, notably, agriculture, science and technology, water and sanitation, education, housing etc.

With so many players, agencies, institutions, involved in health research, it is but natural that there would be duplication, redundancy, lack of coordination and direction. Even within Indian Council of Medical Research there was no coherent research policy till 2007. In the same year the Government of India created a Department of Health Research (DHR) within the Ministry of Health. The creation of a new Department gave a clear message that research would play an important role in shaping country’s health policies and programmes. Embedded in its charter of business is the intent of making better use of research evidence in decision making. To improve governance of health research the Department has drafted inter alia a National Health Research Policy. In doing so it draws on the Health Research Policy of the ICMR.

The Ministry of Health had enunciated a Health Policy in 2002 and recognized that the funding for research was meager and prescribed that it should increase to 1% of total health spending by 2005 and to 2% by 2010. While making the allocations for the 11th Plan, health research received Rs 4496 crores (3%) from the total outlay of nearly Rs 146,000 crores. Although this amount meets the promise of the NHP but is woefully inadequate when one considers that the allocation for health is itself quite low. The NHP 2005 and the UPA-II’s Common Minimum Programmes promised to raise the health expenditure by the Central government to 2% of GDP by 2010. However the figure has remained under 0.4% during the period 2006-11.

Health is a fundamental right of all people. It is also now recognised as a fundamental issue in National Development and a factor that promotes equity. An evidence-base developed by appropriate research should be the basis of health systems and services. The global imbalance in the allocation of resources for health research, the 10/90 dis-equilibrium, has resulted in a low priority for research on the pressing health problems of much of the developing world. India is fortunate that significant resources are allocated for research and that funds are available in a diversity of fields and disciplines to be used for health research.

The NHRP Statement: A clearly defined health research policy therefore, is the basis for maximizing the returns on investments in health research through creation of a health research system to prioritize, coordinate, facilitate conduct of effective and ethical health research and its translation into products, policies and programmes aimed at improving health especially of the vulnerable populations.
The draft Policy lays down a strategic vision for health research in India. It prescribes creation of a National Health Research System to be managed by a National Health Research Management Forum, and suggests a 10-point action programme.

**National Health Research System**

In order to achieve the objectives set out in the National Health Policy, 2002, the targets identified in NRHM, as well as global commitments such as MDG IHR, 2005, we need to conduct research to improve our understanding of the issues and problems, improve better utilization of existing tools, develop tools where necessary, and formality and effectiveness of new strategies.

**National Health Research System (NHRS)**

It has been envisaged that health research in the country should be developed into a National Health Research System (NHRS) wherein all research agencies, cutting across Ministries and sectors identify priority areas of research and coordinate with each other to avoid duplication, fragmentation, redundancy and gaps in knowledge, in order to enable the results of research to transform health as a major driving force for development. In this system all research agencies-cutting across Ministries and sectors, identify research priorities and coordinate with each other to avoid unnecessary duplication, fragmentation of effect.

**Goals of the NHRS**

The NHRS would have three main functions viz. generate and communicate knowledge that helps to form the national health plan and guides its implementation, and thus contributes, directly or indirectly, to equitable health development in the country; adapt and apply knowledge generated elsewhere to national health development; and to contribute to the global knowledge base on issues relevant to the country

**Responsibilities of the NHRS**

The National Health Research System would identify priority areas of research, coordinate to avoid duplication, fragmentation, redundancy, address gaps in knowledge, and enable the results of research to transform health as a major driving force for development. The System would steer the preparation of national health research plan for Five-Year Plans, and would recognize important role various stakeholders plays in health research, and ensure good governance of health research while adhering to highest principles.

**The National Health Research Management Forum (NHRMF)**

A large amount of research is carried out in India by a multiplicity of organisations and Institutions and sponsored by a variety of governmental agencies and international sponsors. There is no agency for coordination of this large endeavour and avoidable duplication and unhealthy competitiveness. It is an unfortunate feature. The Ministry of Health & Family Welfare is the nodal Ministry for Health and is primarily considered as a ‘social sector ministry’. The reality of the necessity for a scientific evidence-base for the optimum delivery of health care requires that research is essential. Further, the rapid advances in modern biotechnology in the health field means that unless India is able to respond effectively the role of health being an engine of development will remain as a dream in our country. The key to future success in this field is dependent on a coordinating role for the nodal ministry with the willing cooperation of all others concerned to develop a National Health Research System. Efficient coordination, planning and financing of the NHRS requires the establishment of a National Health Research Management Forum.
An overarching National Health Research Management Forum is proposed, having representation of all key stakeholders, the DHR as its Secretariat, The Forum would advise on and evolve national health research policies and priorities and to evolve mechanisms and action plans for their implementation develop a 5 year projection of the plans for health research and to prepare an annual National health research plan conduct mid-Plan appraisal for course correction, as needed. It would also promote the development of health research activities in the country; review biomedical & health research management, and suggest strategies to overcome problems in implementation of policies; suggest mechanisms to nurture a scientific environment to attract talent and to develop human resources for biomedical and health research; and finally facilitate utilisation and dissemination of research results and advocacy for Health research

The NHRF would ensure quality leadership, productivity, strategic direction and coherent action, provide strategic vision, priority setting, performance and impact assessment, promotion and advocacy, setting of norms, standards and frameworks for the sound practice of research among others. It would address issues related to resource generation, targeted allocation and judicious utilisation. The Forum would ensure that the research process does not end with knowledge generation, but includes the translation of results into policy or action, or absorption into the existing knowledge / technology base. It would also adopt a long-term approach to the development and maintenance of research capacity.

Structure of NHRMF

The NHRMF will be chaired by the Minister of Health & Family Welfare and co-chaired by Minister of Science & Technology. The Minister(s) of State for Health would be the Vice-chairperson(s). The Secretariat shall be in the DHR and its Secretary shall be the Member-Secretary. All Secretaries of various science departments in S&T would be the members, DGHS and 3-5 eminent scientists/ public health experts would be the other members

The 10-point action programme

i. Generate the evidence base for Health Systems and Services, to be significant promoters of equity and contribute to National Development so that health research becomes a poverty reduction tool.

ii. Establish linkages between health research and national health programs to identify key operational issues and facilitate the operationalisation of evidence based programs and to obtain feedback for the optimisation of Health Research.

iii. Foster translational research to ensure that the products of basic research can be appropriately utilized in health systems and services.

iv. Encourage the development of fundamental research in areas relevant to Health, such as Physiology, Biochemistry, Pharmacology, Microbiology, Pathology, Molecular Sciences and Cell Sciences, to ensure that a national critical mass of Scientists who can contribute the benefits of modern technology to Health research is developed.

v. Facilitate priority setting to guide the direction of health research and prepare rolling planning and strategy documents.
vi. Build and integrate capacity for research in National Health Programmes, Research Institutions and in the Private sector (profit and non-profit organisations) especially in rural and urban research centres utilising as far as possible areas of excellence already available in the country.

vii. Ensure that the global knowledge base is available for National programmes, and that research is channelled in relevant directions without unnecessary duplication by the optimal use of Information, Communication and Networking technology.

viii. Manage global resources and transnational collaborations optimally to ensure that collaborative health research primarily facilitates the development of National Health Systems and Services.

ix. Ensure true intersectorality of health research and harness the resources in areas such as Social Sciences, Economics and traditional systems of Medicine.

x. Harmonize National Policies in a variety of areas (Education, Social Sciences, Population, Agriculture, Nutrition, Trade, Commerce, etc) to facilitate intersectoral collaboration and partnership, so that maximum developmental returns can occur from Health research.

**Summary**

At a time when it is increasingly being recognized that health is a driver of development, it is very appropriate that a National Health Research Policy is enunciated. As the causes of ill health are multi-dimensional at the efforts to find solutions have also to be multi disciplinary. No single agency can do it alone. Creation of a National Health Research System and a National Health Research Management Forum would help to give a clear direction, set combined priorities, pool resources and ensure not only generation of new knowledge but its utilization and management. The final aim is to translate knowledge into products that would help to achieve the targets set in National Health Policy and accelerate the progress toward achievement of MDGs.
Information & Communication Technology (ICT)
Dr. Daniel Nepelski
The Concept and Evidence of ICT R&D Internationalisation

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Introduction

This paper explores how information and communication technologies (ICT) research and development (R&D) is taking place across various regions of the world. It analyses the dynamics of the R&D internationalisation process, i.e. the process of conducting R&D-related activities in other regions than a company's country of origin (Kuemmerle, 1997). The motivation behind taking up the subject of internationalisation of ICT R&D activities are manifold. This analysis is partly driven by the following three concerns:

First, the scarcity of data illustrating the developments in ICT R&D activity creates a challenge for informed policy making. In particular, the process of R&D internationalisation challenges the available tools for measuring inventive performance. To track the inventive activity, Business Enterprise Research and Development (BERD) data and company data are used. However, as such data is typically assigned to a particular geographical location or company, it fails to capture the full dynamics of the inventive process that is increasingly taking place across national or regional borders. This, of course, is putting at risk the decision making process by giving partial view of the reality. Better grasping the internationalisation process and the corresponding data might help to disentangle such dynamics.

Second, following the internationalisation of their production activities, large multinational companies are increasingly internationalising their R&D activities (Kuemmerle, 1997). If most international R&D activities of EU firms still seem to take place within the EU and between the EU and the USA (UNCTAD, 2005), there also seems to be an emerging internationalisation trend towards Asian countries (Van Der Zee, 2006). The increasing role of developing countries, in particular in Asia, may create additional competition for R&D resources and may lead to a reduction of the amount of R&D investments in the advanced economies. This creates a concern of policy makers that the location of R&D facilities abroad might have a negative impact on domestic R&D expenditures and employment and on the domestic knowledge base.

The above concern is additionally amplified by the fact that internationalisation of R&D is primarily taking place in knowledge intensive industries, such as the ICT, chemical or pharmaceutical sectors, in other terms in industries seen as essential to advanced economies. It is perceived that the potential loss of local inventive capacities in these industries to the advantage of other regions might harm the competitiveness of these industries and undermine the advanced economies. However, the internationalisation of R&D may also have positive effects for the advanced economies. For example, by accessing a wider pool of knowledge, companies improve their competitiveness with a potential for positive spill-over effects at home also (Branstetter, 2006; Todo, 2006). Furthermore, by building up research facilities abroad, firms get access to potentially relevant knowledge located outside their original location (Kuemmerle, 1997). Similarly, because firms need to increase the pace at which they bring products to the markets, they need to be close enough to react and adapt to local market needs. Thus, these knowledge flows might positively affect the overall knowledge creation balance and the
inventive capacities of individual countries. To better understand these effects, a sound assessment of R&D flows is needed.

To address the concerns and complexities resulting from R&D internationalisation outlined above, it is necessary to follow the developments of the global knowledge creation network with particular attention to the complexity of the knowledge creation process and companies’ strategies to decide on R&D sites location. Towards this aim, the current analysis attempts to create a snapshot of the current status of the R&D internationalisation and to investigate the position of major world regions in this process.

The following analysis uses the methodology of analysing R&D internationalisation that divides the process of R&D into two stages. The first one concerns the input-side of the R&D process and the second one the output side of R&D activity. Such division reflects some of the complexity of the R&D process and, hence, allows for a more accurate assessment of the internationalisation of R&D activities.

The remaining of the paper is organised as follows: Section 0 of discusses the concept of R&D internationalisation. This discussion serves as a framework and as a starting point for a set of empirical analyses of R&D internationalisation in the ICT sector in Section 0. In particular, section 0 investigates the geographical distribution of ICT R&D sites and section 0 describes the empirical evidence of internationalisation of the inventive activity in ICT based on patent statistics. Section 0 summarizes the main results and concludes.

2. The concept of the internationalisation of inventive activity

Over the last decades, an intensive process of redistribution of production across the world has been observed (van der Zee, 2006; OECD, 2009). This process is an illustration of how the allocation of production resources responds to disparities in regional conditions of production (Massey, 1979). The outcome of these flows is an increasing internationalisation of the environment in which companies operate. Trade, foreign direct investment (FDI) and the offshoring of manufacturing have been the most visible form of this internationalisation.

There are both macro- and microeconomic causes for the international redeployment of resources (Massey, 1979). At the macroeconomic level, one of the main drivers of internationalisation of economic activity has been the growing openness of the international trading system and reductions in duties and the gradual lowering of non-tariff barriers. The liberalisation of capital movements has additionally increased the level of international integration eliminating the restrictions on FDI. In addition, the development of modern transport and communication technologies has drastically reduced the costs of moving goods, people, and information across the world and has made the integration of markets across borders easier.

At the microeconomic level, there have been three elements concerning the economic and production process that facilitated a spatial division of labour and the internationalisation of production. First, the growing vertical and horizontal dimensions of firms and increase in their size were responsible for a number of considerable changes in organisational forms of firms. Examples of such organisational changes include the separation and decentralisation of technical control, and management functions and the division of the production process into separately functioning stages. This, in turn, allowed firms to spatially divide the value chain and distribute distinct stages across different locations. Second, the growing competition has increased the pressure to cut labour costs and increase productivity, which in turn accelerated the process of product standardisation, automation of production, and the introduction of ICT-based processes in manufacturing. Combined with
modularisation of production, the increasing trend of product standardisation has further allowed for a geographical separation of different phases in the production process. Third, parallel to the changes in the organisation of economic activity and production, the structure of the economies in the developed countries has changed. New sectors, such as electronics or telecommunications, are playing an increasingly important role. One of the common characteristics of these industries is the type of competition, which is based on fast speed of technological change. The exposure to constantly changing conditions increases the relative importance of research and development in the national employment structure and reduces the reliance on the workforce involved in the manufacturing activities.

As a result of the above discussed changes, the transformations in the production process and the structure of economy have accelerated the process of spatial redistribution of labour according to the requirements of each activity and the pattern of regional conditions. This, in turn, has led to the internationalisation of production.

As part of the process of spatial division of economic activity, a new trend seems to have emerged over the last years. A number of large corporations have slowly moved away from the strategy of locating only production facilities outside their home country with the aim of manufacturing products developed in their home county at a lower cost and, instead, have begun to seek new knowledge opportunities worldwide (Bartlett and Ghoshal, 1990; Dunning, 1994). The new breed of so-called "metanational" companies is increasingly building a new kind of competitive advantage by discovering, accessing, mobilising, and leveraging knowledge from a number of locations across the globe (Doz, Santos and Williamson, 2001). This means that firms increasingly tend to locate R&D outside the country where the company is headquartered. This type of spatial division of labour reflects the increasing transfer of sophisticated, knowledge-intensive activities to other locations than companies' domestic markets. Such behaviour contrasts with the traditional approach of projecting home-country experiences to other locations and keeping high value-added activities such as R&D, marketing, and strategy at headquarters.

Another important observation of the available studies on R&D internationalisation is that this process remains apparently limited to a small number of developing countries and economies in transition (UNCTAD, 2005). R&D related investment flows remain concentrated mainly within and between the highly developed countries: US, Japan and European countries. This, however, is forecasted to change over time (OECD, 2005). As the process of changing geography of the technology-intensive industry continues, Asian countries are becoming an essential link in the global value chain and are increasing their importance and attractiveness as location for higher value-added firm activities such as R&D. There are already signs that Asia is becoming the target for new collaborations in innovative efforts, both within Asia, and between OECD countries ICT firms and Asian partners (OECD, 2009).

Despite the fact that the topic of R&D internationalisation has already attracted a considerable amount of attention, there is still relatively little empirical evidence of the existence of considerable outcomes of this type of activity, e.g. a significant number of international patents (see section 0). For example, in one of the pioneer studies on the subject, by analysing the patenting activity of U.S firms, Patel and Pavitt (1991) found that the technological activities of multinational firms are concentrated in their home country. More recent studies do not show significant changes with respect to the internationalisation of R&D activity either (Picci, 2009; Di Minin, 2006). In other words, the observed output of international inventive activity is apparently remaining low. Similarly, Ariffin and Figueiredo (2006) report results that run counter to some existing generalisations concerning the
direction of knowledge and expertise flow between developed and developing countries. By studying a number of selected firms in the electronics industry in Malaysia and Brazil, they find that these firms have managed to develop significant levels of innovative technological capabilities without external stimulus.

Most of currently available studies conclude that, in general, features of the R&D process, such as the multidisciplinary and tacit knowledge inputs and the commercial uncertainties surrounding outputs, create considerable challenges to the management of globally dispersed R&D activities (Bo, 2006). In addition, as illustrated by an empirical analysis of the determinants and barriers of R&D internationalisation, both geographical and cultural distance inhibits international collaboration between researchers. Consequently, tangible outputs of international inventive collaboration remain still scarce. Nevertheless, there is also broad agreement that the process of R&D internationalisation will intensify over time.

3. Empirical evidence of the internationalisation of ICT R&D

3.1 Methodology: disentangling the R&D value chain

In spite of the abundance of anecdotal evidence regarding R&D internationalisation, scarce systematic analysis have been organised and very low levels of international inventive collaboration are that far observed. These somehow puzzling results can be explained by the complexity of the inventive process and various motivations that are behind the decisions to do R&D abroad. For example, as explained earlier, not all R&D activities are carried abroad with the aim of delivering new inventions that can then be patented and transferred to other locations. Instead, some of them are meant to adapt existing products and technologies to new markets and consumer preferences. Moreover, such features of the R&D process as multidisciplinary and tacit knowledge inputs and commercial uncertainties surrounding outputs create considerable challenges to the management of globally dispersed R&D activities (Bo, 2006) and, as a result, tangible outputs of international inventive collaboration remain scarce or at least, extremely difficult to observe and measure.

To address the complexities related to R&D internationalisation outlined above, it is necessary to follow the developments of the global knowledge creation network, with particular attention to the complexity of the knowledge creation process and its stages. To this end, the following analysis uses the methodology of analysing R&D internationalisation as presented in the Figure 3-1.

To put it simply, and as presented in Figure 3-1, the process of R&D can be divided into two stages. The first stage concerns the input-side of the R&D process and the second one the output side of R&D activity. Such division reflects some of the complexity of the R&D process and, hence, allows for a more accurate assessment of the internationalisation of R&D activities. Thus, following this division, the level of internationalisation of each R&D stage will be analysed separately.
3.2 Internationalisation of ICT R&D input

The following analysis attempts to create a map of ICT R&D sites of major ICT companies and, on this basis, to assess the internationalisation of their R&D infrastructure. In particular, section 0 tackles two questions: First, how does the regional distribution of ICT R&D sites (of the considered companies) look like? Second, where do companies from different regions of the world locate their R&D sites? In other words, the analysis focuses on explaining where the knowledge of the ICT sector is being produced and what are the geographical origins of companies owning these ICT knowledge production sites.

The analysis in this section is based on information included in the JRC IPTS ICT R&D Location database. This dataset includes location information about over 1800 R&D sites that, in 2008, belonged to 80 multinational companies that are considered to be major semiconductor influencers. The methodological box below describes in detail the process of creation of this dataset.

It has to be noted that the results presented below are only descriptive evidence that does not provide insights into the type, size, quality or scientific complexity of activities performed in these R&D sites. In other words, the mere number of R&D sites might be misleading when trying to conclude about the importance of firms' presence in a particular location. As argued above, there are various reasons for conducting R&D abroad and, as a result, the amount of effort and resources invested by companies in various R&D sites might vary. Therefore, the evidence presented here should be interpreted with caution.
The JRC IPTS ICT R&D Location database contains information on over 1800 ICT R&D sites that belong to 80 ICT companies. Companies included in the database are considered to be the major 'semiconductor design influencers' and therefore essential industrial actors in the ICT value chain. It has to be noted that the selection of companies included in the IPTS ICT R&D Location database was based on expert knowledge and does not cover the entire ICT industry, but instead, attempts to cover companies which are considered to have the major impact on the ICT value chain.

In addition to the basic information on R&D sites, such as OEM name, R&D site name and location, the dataset includes very detailed information on the type of activity conducted at nearly each site and, to a limited extent, its size.

Part of this information was collected by iSuppli's on behalf of JRC-IPTS during the period 2007-2008. Information about companies' geographical origins was in general extracted from the EU Industrial R&D Investment Scoreboard dataset. When necessary, the Goliath database of the Gale Group and the Amadeus database by Bureau van Dijk were also used to identify the country of origin of companies.

Regarding the regional coverage, the dataset includes over 40 countries and allows assigning them to one of the four major regions that play the most important role in the development and production of ICT products. These regions are:

- **Americas Region**: North, South, and Central America, Caribbean countries,
- **Asia-Pacific and Central Asia (APAC) Region**: India, Southeast Asia, China, South Korea, Taiwan, Philippines, Australia, New Zealand, Indonesia, Indian ocean and Pacific ocean countries,
- **EMEA Region**: Europe, Russia, Middle-East to the India border, and Africa,
- **Japan**.

### 3.2.1 Global distribution of ICT R&D sites

The analysis starts with a first look at the global distribution of ICT R&D sites across the four major world regions listed in the above box, i.e. Asia and Pacific, Americas, Europe and Middle East, and Japan, also looking at the headquarter location of companies owning these sites. Then, it examines where ICT companies from different regions locate their R&D sites.

**Global distribution of ICT R&D sites by location and ownership**

Figure 3-2 reveals some patterns of global distribution of ICT R&D sites. First, by including a breakdown by site location in one of the four world regions, it shows companies' preferences for

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1 See at: [http://www.isuppli.com/](http://www.isuppli.com/)

location selection for conducting R&D activities. Second, it indicates to whom these R&D sites belong.

Concerning location of ICT R&D sites, Figure 3-2 reveals that one third of 1808 ICT R&D sites belonging to the major influencers of semiconductor design is located in the Americas region. The EMEA region and Japan host an equal but smaller share of ICT R&D sites, i.e. 24% in each region. Finally, 22% of all ICT R&D sites are in the APAC region, which is only 2% less than in the entire EMEA area. Regarding ownership of R&D sites, Figure 3-2 shows that firms with headquarters in the Americas region own 36% ICT R&D sites and, with 35% of all R&D sites, Japan is the second largest owner of ICT R&D sites. Companies from the EMEA region account for twice as many R&D sites as their APAC counterparts which own only 10% of all ICT R&D sites.

A simple comparison of the information concerning the location and ownership of ICT R&D sites reveals that only the regions of Americas and Japan can be considered as net exporters of ICT R&D sites. That is, the number of R&D sites owned by companies from these regions is greater than the number of sites located there. By the same token, the APAC and EMEA regions are net importers of R&D sites.

*Where are ICT R&D sites located and who owns them?*

Figure 3-3 shows the regional distribution of ICT R&D sites and the region of origin of companies owning them in 2008.
ICT R&D sites located in the EMEA region: Out of 442 ICT R&D sites located in the EMEA region, 45% of them are owned by EMEA companies and 32% belong to companies with headquarters in the Americas region. The remaining 23% are distributed between companies headquartered in Japan (16%) and the APAC region (7%).

ICT R&D sites located in the APAC region: Likewise, out of 399 ICT R&D sites located in the APAC region, 29% of them are owned by APAC companies and 31% belong to companies with headquarters in the Americas region. The remaining 40% of R&D sites located in the APAC region are nearly equally distributed between companies headquartered in the EMEA and Japan region.

The example of the APAC region is the only case where the share of R&D sites belonging to companies from another region (Americas: 31%) is higher than the share of R&D sites owned by local firms (APAC: 29%). Furthermore, it needs to be noted, that these are American companies that hold the leading amount of sites in the ICT R&D in the APAC region, i.e. 31% vs. 22% for Japan and 18% only for EMEA. Thus, this observation tends to confirm the strong position of American companies in the Asian region in terms of both production and research activities.

In all of the remaining regions, local companies hold the highest share of R&D sites. However, there are considerable differences. For example, whereas the EMEA region shows a very high share of foreign-owned R&D sites (55%), only one third of the R&D sites located in the Americas region are controlled by foreign companies. Regarding the Japan region, local companies own the lion's share of R&D sites, i.e. over 90%, and R&D sites of firms from the other regions are nearly nonexistent.

As seen above, the largest share of foreign R&D sites located in the region of EMEA is controlled by American companies (one third). This might suggest that, like in the case of the APAC
region, the considerable presence of the American companies in Europe is positively correlated with the inventive output measured by the number of patented inventions that American researchers develop together with their European counterparts (see section 3.3.3).

Where do ICT companies locate their R&D sites?

Figure 3-4 shows the location of ICT R&D sites with respect to the origin of the company's headquarters. This data allows for casting some light on companies' decisions concerning the location of their R&D sites in one of the four world regions.

**Figure 3-4: Global distribution of ownership of ICT R&D centers located in five regions of world, 2008, in %**

R&D sites owned by companies headquartered in the EMEA region: Out of 353 R&D sites owned by companies headquartered in the EMEA region, 57% were located in the EMEA region. The other most frequent locations for R&D activities among the firms headquartered in the EMEA region were the countries from the APAC (20%) and Americas (19%) regions. Only 4% of R&D sites owned by EMEA companies were located in Japan.

R&D sites owned by companies headquartered in the APAC region: Likewise, out of 174 R&D sites owned by companies headquartered in the APAC region, 67% of their R&D sites were located in the APAC region. The other most frequent location for R&D activities among the firms headquartered in the APAC region were the countries from the EMEA (17%) and Americas (13%) regions. At the same time, only 3% of R&D sites owned by APAC companies were located in Japan.

Other regions: The pattern of locating R&D activity close to a company headquarter is very common among firms from other regions as well. However, the data shows that whereas companies from the Americas and EMEA regions have over 40% of their R&D sites in other regions, their
Japanese counterparts maintain over 60% of their R&D sites in Japan. Although this level of domestic ownership of R&D sites located in a particular region is only slightly lower than in the APAC region, it confirms the generally low level of internationalisation of Japanese firms.

As of 2008, American ICT firms seemed to consider the EMEA countries as most attractive for locating a R&D site. 22% of all American research sites are located in the EMEA region. However, despite the long-standing R&D collaboration between US and EU firms and researchers, as illustrated by the level of joint patents (see section 0), the data indicates that the APAC region is nearly equally attractive to American companies for establishing a R&D site as the EMEA one. In 2007/08, the APAC region hosted only 3% less of American R&D sites than the EMEA region. In addition, European countries were the least attractive for conducting R&D activities from the perspective of the Japanese firms. Only 11% of all the R&D sites owned by Japanese firms were located in the EMEA region.

The analysis of the data allows for drawing some first conclusions on the patterns of R&D investments between the major world regions. Overall, it confirms the existence of strong linkages between the US and Europe in scientific and technological cooperation and mutual investments in R&D activities. However, it also clearly shows the increasing attractiveness of the APAC region as a destination of R&D investments. Companies from all major economic regions seem to share this view and, as the data reveals, the most frequent location for EMEA ICT R&D activity is the emerging Asian economies.

**Internationalisation of the ICT R&D output**

The previous section provided a mapping of the global distribution of ICT knowledge production infrastructure. This mapping allowed for analysing the internationalisation of ICT inventive activity by looking at it from the input side of inventive activity. In contrast, the following section attempts to measure and identify inventions that have been developed as a result of international collaboration. To this aim, patent data are analysed.

Several researchers have already exploited in various ways the information contained in patent data (see, among others, Patel and Pavitt, 1991; Patel and Vega, 1991, and Le Bas and Serra, 2002). However, while most previous studies have considered the patent portfolios of firms, here patents are attributed to countries, by exploiting the fact that patent data provide separate information on the place of residence of the inventors and of the applicants. Thus, it is possible to track the output of inventive activity conducted by actors residing in different countries and regions.

The source of the data is here also the European Patent Office Worldwide Patent Statistical Database (PATSTAT). The methodological box below describes the approach of this study to analyse the internationalisation of ICT inventive output by using patent statistics. It has to be noted that this ICT inventive output is not only produced by the ICT sector, but also by other sectors of the economy, such as automotive, aeronautics, etc.

The remainder of the Section is organised as follows: Section 0 compares the internationalisation level of the EU and the US. Section 0 assesses the level of inventive collaboration between EU and US. Section 0 compares the levels of collaboration between EU and Asia and between US and Asia.
Patent-based measures of R&D internationalisation

Each patent application has a list of inventors, i.e. persons who developed a particular invention, and a list of applicants, i.e. persons that own the property rights over this invention. This analysis uses measures of internationalisation that are based on the presence of inventors and/or applicants residing in different regions of the world among the list of persons who file a patent application. An "international" patent application is defined in the analysis presented here as an application with people and organizations residing or located in different countries or regions, e.g. in the US and the EU. It is however important to note that, intra-EU patent applications are not considered here as international patents. For example, a patent application having only a German inventor and/or applicant and a French inventor and/or applicant, is not considered here as international.

Four concepts of internationalisation of a given patent are used in the analysis:

**Inventor international collaboration**: A patent with at least two inventors residing in different countries or regions, e.g. a patent with an EU and a non-EU inventor. This concept captures international co-inventions and is used to construct a relative measure of international collaboration between inventors. This measure is defined as the share of a country's inventions with inventors residing in the country and inventors residing outside the country, in the country's total number of inventions (according to the inventor criterion).

**International co-ownership of inventions**: A patent with at least two applicants residing in different countries, e.g. a patent with an EU and a non-EU applicant. This concept is used to construct a measure of international co-ownership of inventions. This measure is defined as the share of a country's inventions co-owned by applicants residing in the country and applicants residing outside the country, in the country's total number of inventions (according to the applicant criterion).

**Cross-border ownership of inventions**: There are two concepts associated with this type of internationalisation that capture the notion of cross-border ownership of patents:

1) A domestic invention is owned by a foreign applicant. This concept captures foreign ownership of domestic inventions. It is used to construct a relative measure of foreign ownership of domestic inventions. This measure is defined as a share of a country's inventions owned by applicants residing outside the country, in the country's total number of inventions (according to the inventor criterion).

2) A domestic applicant owns a foreign invention. This concept captures domestic ownership of foreign inventions. It is used to construct a relative measure of domestic ownership of foreign inventions. This measure is defined as a share of a country's ownership of foreign inventions in the country's total number of inventions (according to the applicant criterion).

The above defined measures of internationalisation are computed by using data that originates from the EPO Worldwide Patent Statistical Database (also known as EPO PATSTAT). This database compiles raw patent data from over 80 countries. In the following analysis, the data from the April 2009 database release is used. The time span for which the indicators were computed is between 1990 and 2006.

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The analysis is carried out using a methodology that considers all priority applications filed at all 27 EU national patent offices, at the European Patent Office (EPO), and at the United States Patent Office (USPTO).

**R&D collaboration: the EU vs. the US**

**Collaboration between inventors and co-ownership of inventions**

Figure 3-5 illustrates the levels of inventor collaboration and co-ownership of inventions for ICT inventions for the EU and the US for the period between 1990 and 2006.

**Figure 3-5: Shares of inventor collaboration and co-ownership of inventions, EU vs. US, ICT inventions, 1990-2006**

According to Figure 3-5, the degree of inventor collaboration and co-ownership of inventions in the US and the EU has been very similar over the period considered in this analysis. For example, in 2006, the share of ICT inventions with both EU and non-EU inventors in the total number of EU ICT inventions was roughly equal to the share of ICT inventions with both US and non-US inventors in the total number of US ICT inventions, i.e. 1.5%. Furthermore, in both regions the degree of inventor collaboration is higher than the level of co-ownership of inventions. Note that the above shares are still quite low. They are however rising.
Cross-border ownership of inventions

Figure 3-6 illustrates the level of the EU and the US cross-border ownership of inventions for ICT inventions for the period between 1990 and 2006.

**Figure 3-6: Shares of cross-border ownership of ICT inventions, EU vs. US, 1990-2006**

According to Figure 3-6, in 2006, around 9% of the EU ICT inventions were owned by foreign applicants. In contrast, in the same year, less than 4% of the US ICT inventions were owned by non-US applicants. The reverse pattern can be observed for the share of foreign inventions owned by EU and US entities. In 2006, only around 5% of EU-owned ICT inventions were developed by foreign inventors. In the same year, more than 7% of all inventions owned by US applicants were the result of foreign inventive activity.

The comparison of the data presented in Figure 3-6 reveals the presence of an important difference: in the US, there are significantly more US applicants filing patent applications including foreign inventors, than in the EU. In contrast, many EU inventors file patent applications with foreign firms. Thus, compared to the US, the share of foreign ownership of EU ICT inventions is much higher than the share of the EU ownership of foreign ICT inventions. In other words, the above analysis

Note: Priority patent applications filed to European national patent offices, at the EPO, and at the USPTO. Invention counts are based on the inventor or the applicant criterion, the priority date and fractional counts.

*Source*: IPTS calculations based on PATSTAT data.
reveals that US companies are more likely to own both US and non-US ICT inventions, than EU companies.\(^4\)

The analysis of the results of Figure 3-5 and Figure 3-6 leads to the following conclusion: Whereas the degree of inventor collaboration and co-ownership of inventions in the EU and the US are similar, the levels of cross-border ownership of inventions are very different. The share of foreign ICT inventions owned by the US applicants is higher than share of foreign ICT inventions owned by EU applicants. Thus, the US strength in internationalising the process of inventive activity seems to stem from both a higher propensity to own inventions developed in overseas locations and from more intensive collaboration with foreign researchers.

**Inventive collaboration between the EU and the US**

So far only the level of internationalisation of inventive activity of a given country or region was considered irrespective of the identity of the collaborating countries. In the following, the mutual relations that exist between countries or regions are analysed. This section examines the collaboration between the EU and the US. Next, Section 0 presents equivalent measures for the collaboration between EU and Asian inventors and applicants and between US and Asian inventors and applicants.

**Collaboration between EU and US inventors and EU-US co-ownership of inventions**

Figure 3-7 illustrates the level of collaboration in developing ICT inventions between EU and US-based inventors and the level of EU-US co-ownership of inventions. The covered period includes years between 1990 and 2006.

\(^4\) These indicators need to be interpreted with caution, as the filing practices to the USPTO and EPO or EU national patent offices are slightly different. In this particular case, it needs to be taken into account that, at the USPTO, the inventor is the applicant filing a patent application.
Figure 3-7: Shares of international inventions with EU and US collaboration, ICT inventions, 1990-2006

![Graph showing shares of international inventions with EU and US collaboration, ICT inventions, 1990-2006.](image)

Note: Priority patent applications filed to European national patent offices, at the EPO, and at the USPTO. Invention counts are based on the inventor or the applicant criterion, the priority date and fractional counts.

Source: IPTS calculations based on PATSTAT data.

According to the results presented in Figure 3-7, the values of the measures of collaboration between EU and US inventors and of EU-US co-ownership of inventions are very low. In the period of analysis, they remain below 1% of the total number of EU ICT inventions, although they increased significantly since the early nineties.

These small numbers have to be seen in a broader perspective. The overall levels of international patents is very low and, as it is shown in the forthcoming section, collaboration levels between researchers and applicants from other regions are even lower. Thus, although very low in absolute numbers, the level of inventor collaboration or co-ownership of inventions between EU and US is among the highest observed in the current analysis.

**Cross-border ownership of inventions by EU and US applicants**

Figure 3-8 compares the share of European patent filings that include applicants from the US to the share of US patent filings that include applicants from the EU for ICT inventions for the period between 1990 and 2006.
According to the results presented in Figure 3-8, over the entire period of analysis there have been two to three times as many US applicants filing patents with EU inventors, than vice versa. For example, in 2006, nearly 6% of all EU inventions were owned by US applicants. In the same year, only around 2% of American inventions were owned by EU applicants.

An analysis of the data reported in Figure 3-8 shows that the gap in cross-border ownership of inventions between EU and US has remained unchanged over the entire period of the analysis. This observation might indicate that it could have some structural causes. A possible explanation might be a high preponderance of US firms in producing internationalized ICT patents. Alternatively, it might be a confirmation of the importance of US firms in the EU inventive process, which has been observed earlier (see section 0).

**Inventive collaboration between EU and Asia and between US and Asia**

While the relations, at all levels, between EU and the US have been historically intense in all fields, including the domain of R&D activities, with the exception for Japan, Asia has only relatively recently appeared as an important partner. Thus, the following section analyses the internationalisation of European and US inventive activities with respect to the Asian region.
Collaboration between inventors and co-ownership of inventions EU-Asia and US-Asia

Figure 3-9 illustrates the level of collaboration in developing ICT inventions between the EU and Asian and between the US and Asian inventors and applicants for the period between 1990 and 2006.

Figure 3-9: Shares of inventor collaboration and co-ownership of inventions, EU-Asia versus US-Asia, ICT inventions, 1990-2006

Note: Priority patent applications filed to European national patent offices, at the EPO, and at the USPTO. Invention counts are based on the inventor or the applicant criterion, the priority date and fractional counts.

Source: IPTS calculations based on PATSTAT data.

The results reported in Figure 3-9 illustrate that the levels of collaboration between European and Asian and between American and Asian researchers and the levels of co-ownership of inventions are —still— very low. For example, in 2006, less than 0.4% of all US ICT inventions were developed in cooperation between US and Asian inventors. For Europe, the value of the same indicator was even lower and did not cross the 0.1% mark. Although the levels of co-ownership of inventions for both EU-Asia and US-Asia are also very low, the US-Asia collaboration between applicants is more pronounced than between EU and Asia.

Despite the overall low levels of inventor collaboration and co-ownership of inventions between EU and Asia and between US and Asia, there are some interesting trends in the development of the indicators. First, in the last years, there has been a steep increase of the fraction of inventions developed jointly by US and Asian inventors. Second, after 2000, the US applicants seem to have been more active in collaborating with Asian inventors than their European counterparts.
EU-Asia and US-Asia cross-border ownership of inventions

Figure 3-10 shows the levels of EU and Asia and of US and Asia cross-border ownership of ICT inventions for the period between 1990 and 2006.

**Figure 3-10: Shares of cross-border ownership of international ICT inventions, EU-Asia versus US-Asia, 1990-2006**

The results presented in Figure 3-10 indicate that the measures for both the EU and US ownership of Asian inventions have increased steadily since the early 1990s, but starting at a very low level and being still low in 2006. Even the highest value of the measure reflecting the degree of US ownership of Asian ICT inventions, is below 1.5%. Regarding the Asian ownership of the EU and the US inventions, both figures remain very low as well.

The comparison of the degrees of internationalisation between the EU and Asia versus the US and Asia indicates however the presence of an important difference. After 2000, there has been a rapid increase of the number of US applicants filing patent applications including at least an Asian inventor. In contrast, the share of EU applicants filing patent applications including at least an Asian inventor has remained low over the same period of time. Consequently, in 2006, the share of Asian inventions owned by EU applicants was three times smaller than for the US. Furthermore, over the last few years, the rate of the US inventions owned by Asian applicants has been increasing more rapidly than the EU.
counterpart measure. As a result, today, Asian applicants own more inventions developed by American inventors than by European inventors.

The above observations cast some light on the recent development in the US-Asian relationship. The growth of the US ownership of Asian inventions can be interpreted as representing an increase in patent filings where the applicant is resident in the United States, and inventors are from Asia. Despite the fact that the value of the discussed level of internationalisation is still very low, this might be an early sign of an increasingly intensifying collaboration between Asia and the US.

These observations together with the results reported in Figure 3-10 allow concluding that, in the last years, there has been a fast increase –albeit starting from very low levels- in the share of inventor collaboration between US and Asia and the share of inventions co-owned by US and Asian applicants. At the same time, the levels of both types of collaboration between EU and Asian researchers and applicants remained both very low and stagnant. At least to some extent, this might be explained by the relatively large number of US R&D sites in the Asian region (see a detailed discussion section 0).

Conclusions

Regarding the internationalisation of ICT R&D input, the above analysis revealed the following: First, independently of a firm's headquarter region, most of the firms tend to locate most of their R&D sites in the region in which they are based. The APAC region is the only exception in that respect. In the APAC region, the share of R&D sites owned by firms from the Americas region is higher than the share of R&D sites owned by local firms. Second, when taking into account the number of R&D sites owned by companies from these regions and the number of sites located there, they can be considered as net exporters of ICT R&D sites. By using the same criterion, the APAC and EMEA regions emerge as net importers of ICT R&D sites. Lastly, although it has been confirmed that there are very strong linkages between the triadic countries, i.e. Japan, the US and the EU, the APAC region seems to be very attractive as a location for R&D sites for ICT companies from every region. For example, although for American firms, EMEA countries seem to be most attractive for locating R&D sites abroad, the APAC region hosted only 3% less American R&D sites than the EMEA region. At the same time, EMEA countries seem to the least attractive for locating R&D activities from the perspective of Japanese firms. Also companies from the EMEA area seem to favour the APAC region over the remaining two regions. These results support the increasing attractiveness of the Asian countries as a location for not only production or service facilities but for R&D-related investments as well.

Concerning the patterns of the internationalisation of inventive output by analysing patent statistics, the following can be observed: First, although the output of international ICT inventive activity has steadily increased since the early nineties, ICT research is still highly local and the level of international collaboration, proxied by the number of international inventions measured by patent applications, remains very low. Second, regarding the comparison of the EU and the US, the current analysis reveals some interesting patterns in the internationalisation activity of firms in both regions. Although over the entire period of analysis, the levels of inventor and applicant collaboration in the US and in the EU have been very similar, there is an important difference with respect to the level of ownership of foreign inventions. US firms own significantly more patents including foreign inventors than EU firms do and, at the same time, more EU inventors file patent applications with foreign firms than US inventors do. A possible interpretation is that the US might benefit from the process of internationalisation of inventive activity through both more successfully capturing inventions
developed in overseas locations and relatively higher levels of collaboration with foreign researchers. Lastly, the above analysis casts some light on the position of the Asian region as a destination and source of ICT innovative output and the collaboration of EU and US firms with their Asian counterparts. In general, the level of inventive collaboration with Asian economies in developing ICT inventions was still very low, though increasing over time. However, over the last decade, there have been some important developments with respect to the intensity of the US-Asia collaboration. In particular, since 2000, there seems to have been a steep increase in the fraction of patent applications with US and Asian inventors, whereas the level of collaboration between EU and Asian researchers and applicants seem to have remained stagnant. Furthermore, US firms seem to be much more active in applying for patents on inventions developed by Asian inventors than their European counterparts and, what is equally interesting, Asian firms seem more likely to patent an invention with an American than with a European inventor. These two last observations might be an early sign of the US first-mover advantage in tapping the inventive resources of the Asian region, on the one hand, and of the Asian countries developing inventive collaboration with primarily US partners, on the other hand.

An important outcome of the above analysis is the puzzling picture of the R&D internationalisation. On the one hand, based on the analysed sample, it was seen that up to 43 per cent of ICT firms' R&D sites are located in a different region than the region in which a company headquarter is. On the other hand, however, when the output of the internationalised ICT inventive activity is examined, measured as the amount of patented inventions developed between inventors from different regions, very low levels of international inventive collaboration can be verified. These somehow puzzling results can be explained by the complexity of the inventive process and the variety of motivations that are behind the decisions to locate R&D sites away from the home country. For example, not all international R&D sites are created with the aim of delivering new inventions that can then be patented and transferred to other locations. Instead, some of them are meant to adapt existing products and technologies to new markets and consumer preferences. This might explain why, for example, a strong concentration of American and European R&D sites in Asian countries does not result in a large number of patents developed by these companies together with domestic researchers. Also, it takes time for research activities to result in patent applications and, hence, many recently established R&D centres abroad may not be yet “visible” when looking at available patent statistics.

In conclusion, the preceding analysis contributes to the understanding of the ICT R&D internationalisation process in a number of ways. First of all, it confirms that, when studying the phenomenon of the internationalisation of inventive activity, it is necessary to address its complexity by, for example, disentangling various stages of the process. Second, it delivers a considerable amount of evidence on the internationalisation of various stages of the inventive activity in the ICT sector and allows to assess the position of the major world regions in this process. Lastly, however, it shows that the phenomenon at stake is far from being fully understood and there are still a number of open questions. For example, it is still not clear what the implications of the internationalisation of R&D activities at firm and country level are. It is worth asking how the geographical expansion of R&D activities affects a firm performance and its inventive capabilities. At the country or regional level, there is a question of what is the overall effect of the migration of R&D activities on the local production and inventive capacities. Consequently, as the process of R&D internationalisation has significant implications for countries or regions in which new R&D activities are being set up or from which these activities are being withdrawn, it is worthwhile to spend some more effort on understanding this phenomenon and its consequences.
References


Dr. Bahawodin Baha making his presentation
Enhancing education in Afghanistan through Information & Communication Technology (ICT)

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This paper briefly discusses the relationship between scientific education and economic development. The advances in Information and Communication Technology (ICT) have had a major positive impact on various sectors including education around the world during the last two decades. Therefore, the applications of ICT tools and best ICT practices in basic and higher educational institutions in the developed world are discussed and their incorporation in the educational institutions in Afghanistan is investigated. In addition, recommendations are made on how to improve the education in Afghanistan by integrating ICT within such a system.

1. Introduction

The development in science and technology has revolutionised the world during the last five decades and most people around the world have benefited from such development, as their quality of life has been significantly improved.

The innovation in science and technology has drastically improved the sectors of agriculture, mining, transportation, industry, commerce, telecommunications, IT, etc. The advances in these and other sectors have had a direct impact on the quality of life of people around the world. However, because of decades of wars and instabilities, the people of war torn countries such as Afghanistan have not fully benefited from such a revolution.

The objective of this paper is to explore possible ways to accelerate the applications of the best science, engineering and technology practices which will increase the chances for further development in war torn countries such as Afghanistan, and will improve the quality of life of its residents. A major factor that can contribute to achieving such an objective is the improvement of the quality of education in subjects related to science, engineering and technology, since this will result in a more qualified and experienced workforce capable of drastically enhancing the country’s development.

Limited progress has been achieved in the education system in Afghanistan during the last seven years. For instance, the number of students has increased, some new institutions have been established and effort has been made to upgrade the experience and qualifications of existing academics in such institutions. However, the overall quality of higher education has still not been significantly improved. This paper will investigate the integration of the best possible technological practices and tools that will accelerate the improvement of education in Afghanistan, since enhancing the educational sector is vital for the development, economic prosperity and subsequently stability in the country.

This paper will first present the relationship between scientific education and economic development. The importance of ICT in accelerating the enhancing of education specifically in subject areas related to science and technologies will be highlighted. The application of ICT tools at the educational institutions in the developed world will be discussed and an assessment of the present situation of educational institutions in Afghanistan will be presented. Based on international experience, recommendations will be made to the Afghan government and the international
community on how to incorporate ICT into the education system and hence improve the infrastructure of educational institutions in Afghanistan.

1. Scientific Education and Economic Development

Scientific education is considered crucially linked to national economic development, growth and wealth since it can contribute to the provision of new knowledge and technology and the enhancement of the work force capabilities. The term “scientific” is commonly meant to cover the natural sciences and engineering but it can also be used to encompass the human sciences and humanities (UNESCO, 2001).

Scientific education can be beneficial to both the private and public sector. The private sector can benefit from new knowledge and competence, scientific breakthroughs, new discoveries or inventions, considerably improved products and innovative technical methods. These can lead to better employment prospects, higher salaries, and potential for higher investments, specialised work force, higher economic returns, increased productivity and competitiveness. The public sector can yield benefits through the improved use of new technologies, new or improved services, increase in tax revenue, increase in investments and exports, and thus, the development of a more entrepreneurial society. Moreover, scientific education can contribute to the mitigation of poverty, improvement of the quality of life and population growth. It can be argued that scientific education results in the creation of a nation whose citizens may hold a more active and responsible role in governance as a result of their enhanced knowledge background. From the above factors, it is apparent that scientific education may have a huge impact not only on the economic development but also on the social and political dimensions of a nation.

The impact of the scientific education on development and growth is evident in several published studies. Jenkins (1995) reports that an increase in higher education qualifications (including tertiary and postgraduate) by 1 per cent resulted in an annual increase in the factor of total productivity between 0.42 and 0.63 per cent in United Kingdom. Lin (2004) conducted a study in Taiwan investigating the effect of education in different disciplines. The results showed that higher education had a positive impact on the country's development with scientific education being the most effective. Schofer et al. (2000) examined the effects of the scientific infrastructure on national economic growth over a 20 year (1970-1990) period. The results showed that the size of a nation's scientific work force and training system can affect positively the economic development.

In recent years, a global economy based on scientific knowledge has been established and thus the role of higher education in growth has become more important. However, according to the Task Force on Higher Education and Society (2000), the knowledge distribution between developed and developing countries has become more inequitable. Without an efficient and effective educational policy and implementation plan in place, developing countries cannot benefit from the global knowledge based economy. Lack of scientific knowledge and specialised expertise in developing countries is linked to high levels of unemployment which consequently result in an increase in poverty. Moreover, imports of a high percentage of the total energy and product requirements lead to an increase in the deficit and an unsustainable economic model.

On the other hand scientific education and generation of new understanding can lead to a considerable increase in domestic production which may allow for increased exports. This can enable the developing economies to improve significantly their balance of payments and thus improve the living conditions of their populations. There are also global issues that advocate the significance of the scientific education in developing economies. The rapid growth of the urban population creates new
industrial growth centres and calls for an increased focus on new technologies and their adaptation to
domestic needs.

A study carried out by the UNESCO Institute for Statistics (2001) illustrates the correlation
between the distribution of global science and technology resources and the GDP and population in the
developed and developing countries and economies. The study recommends that reducing this global
imbalance in science and technology resources will be a time-demanding task but will be a significant
factor in alleviating poverty, sustaining development and contributing to peace.

The recent developments in some economies in Asia can provide useful examples of how
scientific education can contribute to narrowing the gap between the growth and wealth in developed
and developing countries. To achieve this goal, it was essential to structure their own national
capacities by using and adapting imported new technologies, implement a production plan, use
innovative materials and capitalise the acquired knowledge through exports of their domestic
production. Several activities must take place before such levels of development are achieved. These
involve a widely accessible higher education system which can provide a continuous supply of highly
trained personnel, a national commitment and an environment that are conducive to high-tech

It is believed that scientific education can contribute significantly to solving some major
problems in low income economies through the following ways:

- Reducing unemployment and increasing the incomes of the poorest classes by encouraging
  investments and creating new job opportunities.
- Improving transport infrastructure.
- Improving the facilities and use of rural and industrial areas.
- Exploring and rationalising the use of national energy resources to cover domestic needs.
- Exploring and developing the use of domestic materials and products.
- Improving the agricultural sector and increasing the quantity and range of food products.
- Improving the health and growth of the population and the quality of life.
- Protecting and developing sustainably the environmental resources.
- Imposing social and economic changes which will stabilise and strengthen efficient
governance.

However, the relative importance of each of the above components and their potential to
enhance national development varies from one country to another. Therefore, there is a need for a
rigorous and integrated national strategy on developing and managing a scientific educational system
which can tackle current problems and achieve future goals.

2. ICT at Educational Institutions in the Developed World

The advances in physics, electronics, and high-speed communications and transportation had a
huge impact on the world during the twentieth century; however, Vest (206) stated that information
and communication technology (ICT), besides nano and bio technologies, are the main challenges for
the twenty first century. ICT is one of the prime technologies that have significantly affected the world
during the last two decades, as everyday life may have been very different without ICT tools in developed countries.

ICT tools are increasingly utilized and adopted at varying pace by established higher education institutions around the world. ICTs are emerging as a part of on-campus delivery as well as open and distance modalities of higher education delivery.

In particular, tools such as email, internet, word processing and presentational software such as PowerPoint are widely utilized at higher education institutions.

ICT tools in higher education are being used for the following purposes:

- developing course material;
- delivering content;
- sharing content;
- communication between learners, lecturers and the outside world;
- creation and delivery of presentations and lectures;
- academic research;
- administrative support;
- managing the institutions;
- finance control within the institutions;
- student enrolment;
- timetabling

The learners (students) can employ ICT to have access to their lecture notes, other educational material at the time and place which are convenient to them either at the university or from a distance. Higher education institutions in developing countries are generally making the most of computers and software available to them. However, challenges including insufficient telephone and telecommunication networks still exist which in most cases slow down the rate of integrating ICT into the education system. The lack of appropriately qualified and experienced specialists in some parts of the world is an additional problem which needs to be tackled.

A major advantage of ICT at universities in the developed world is to share lecture notes, draft textbooks, problem sets, and laboratory experiments and projects. Massachusetts Institute of Technology (MIT), the world renowned engineering and technology institute in the USA has developed an initiative through a program called MIT Open Course Ware (OCW), where teaching material for almost 2000 subjects is available on the internet, free of charge globally. Academics and students at any universities can download such teaching material, adapt it to their needs and new environments, and use it accordingly.

According to Tolani-Brown (2009), ICT tools have been applied for many purposes in the developed world, including distance learning and web-based remotely-accessible laboratories in scientific and engineering disciplines. Emami (2009) stated that remotely-accessible laboratories can provide a unique opportunity for less developed countries where the universities do not have the resources to establish such advanced laboratories within their campuses. This can contribute to the
improvement of the quality of education and the enhancement of knowledge of both academics and students which may thus accelerate the development in such countries.

The introduction and wide application of ICT in developed countries resulted in a major transformation of the traditional classroom education, since nowadays learners can participate in classes and assessment exercises and have access to learning resources from distance without physically visiting the learning environment.

ICT tools have also been extensively applied for research around the world where the information can be found easily and large number of on-line journals is available. It is predicted that the commencement and use of on-line journals will be increased tremendously in the future and most of the good quality journals will be available on-line.

3. The present situation of Scientific Education at Universities and Colleges in Afghanistan

Afghanistan had a progressive and reasonably established education system in the region before the wars and consequent instabilities started in 1979 (Samady, 2001). Since then, the education system in Afghanistan has been devastated as the most well qualified and experienced academics have been forced to leave the country, made redundant or killed. The academics who chose to stay behind have been isolated from the rest of the world for decades and therefore, most of them are currently unaware of the new developments in scientific education around the globe (Baha, 2008).

Since the establishment of the new government in Afghanistan, limited progress has been achieved. The fundamental issues concerning the re-establishment of the scientific education in the country which can significantly contribute to overcoming the nation’s current major problems have not been addressed. According to the authors’ experience, the attempt to enhance the education of subject areas related to science, technology and engineering education has been restricted due to the following reasons:

- weak management;
- the lack of well educated and experienced academic and technical staff;
- the lack of suitable learning resources;
- outdated curriculum;
- lack of practical courses;
- failure to adjust the programmes of study to local needs.

4. Information and Communication Technologies (ICT’s) and Education in Afghanistan

The ICT tools play a major part in educating the new generation in the developed world where the ICT skills are as necessary as reading, writing and basic arithmetic. Therefore, ICT is heavily integrated into primary, secondary and higher education systems around the world. The ICT tools are utilised by the academic and business communities to improve the efficiency of organisations and eventually advance every aspect of life. Therefore, it is highly desirable and beneficial to promote the application of ICT in developing countries such as Afghanistan. The Afghan government has realised the importance of ICT and hence converted the ministry of telecommunications to ministry of communications and IT. Short-term training in ICT tools has been provided for junior and mid-level
managers at many governmental and non-governmental organisations for the past seven years in order to overcome the shortage of ICT professionals in the immediate future. However, such training programmes have not been organised in a uniform and cohesive way to alleviate the long-term gap of the ICT professionals in the country. Regrettably, the progress has been limited despite huge amounts of investment made by the international community in ICT related projects. The only remarkable attempt was the first national conference which was organised by the Ministry of Communications and the United National Development Program (UNDP) and was held in Kabul in 2006 (MoC, 2007).

It is unfortunate that the Afghan government has not considered seriously the integration of ICT into the mainstream education system in the country. ICT can provide a unique opportunity for both academics and students to access a library containing a wealth of information, free of charge via the internet.

An integrated approach is needed by the Afghan government and international community to introduce computers and internet access into the learning environment in Afghanistan; such an initiative will have a major effect on the education system. Since the lack of learning resources such as stocked and up to date libraries and fully equipped computer laboratories is evident in the country, careful planning is required to prioritise the introduction of ICT into the mainstream education including higher education.

While the world has changed dramatically in the past few decades and will continue to do so at an accelerating pace, the learning environment in Afghanistan has remained almost the same. A drastic change in the country’s education system is considered essential in order to follow international norms established by other systems around the world, and ICT can contribute significantly to achieving this objective.

The first undergraduate programme on computer science commenced at Kabul University (KU) in 1997 (Baha, 2010) and since the establishment of the new government in 2002 many other computer science and IT courses have been introduced at several universities around the country. Many computer centres have been founded at Kabul University and other higher education institutions in Kabul and other major cities. Unfortunately, there is little or no collaboration between the various computer centres and their sponsors and this hinders their further development.

5.1. Recommendations

In order to establish an effective higher education system which can actively contribute to the development and growth of Afghanistan, the following recommendations are made:

Strong management teams need to be established at the Ministry of Higher Education (MoHE) and universities in order to tackle the fundamental issues and to lay down the foundations of a suitable higher education system, which will meet the current and future needs of the country. These teams need to have suitable experience, a clear vision and be able to set up a strategic plan of how to further develop the education system.

In the present circumstances, ICT should be integrated into the core curriculum of the main streamline education in Afghanistan, i.e. at primary and high schools, colleges and universities in the country.

ICT policies should be developed at governmental and institutional levels; sound national policies are based upon government priorities and goals, which are associated with the present circumstances in Afghanistan. Policy strategies or approaches to achieving goals may differ, especially in regard to supporting ICT usage and research in higher education institutions in Afghanistan.
National policies which can positively impact on ICT adoption and expansion should focus on promoting access to IT skills and education for all, improving the network infrastructure in urban and rural areas and encouraging technological research and development.

Such national policies and investments in ICT are clearly beneficial to higher education institutions. Undoubtedly, the use of ICT has proved to provide greater access for different types of learners, and has become the vehicle for enriched pedagogical experiences, particularly for distance educators and learners separated by time and space.

There is a strong need that detailed aspects of entrepreneurship ought to be included in the curriculum of the universities in the country. Close collaboration and a coordinated effort is required between various stakeholders who are key players in the country’s development.

A national strategy should be developed and implemented to monitor and evaluate the impact of the current and future use of ICT and other relevant projects in the country.

Suitable training should be provided to the academic and administrative staff members at the education and higher education institutions in the country. Such training may be more efficient, if staff members are committed and willing to learn, and adopt an open-minded attitude towards the application of new practices. Otherwise, even the most elaborate strategy may be hindered from attaining the preset goals.

In order for higher education, including engineering education, to play a vital role in the reconstruction and future development in Afghanistan, significant investments in term of resources are needed to address the issues discussed in this paper.

6. Conclusions

Improving education in the disciplines of science, technologies and engineering is essential for the future development of Afghanistan. ICT can contribute significantly to accelerating the improvement process of the overall education system in the country. It is believed that the integration of ICT into the country’s education system will probably result in increasing access through distance learning, enabling the establishment of a knowledge network for students and academics and broadening the availability of quality education materials.

ICT can create the foundation for a more effective organization, administration and management of the educational institutions. This can be achieved through evaluation of programmes of study and personnel, monitoring of the educational economics and productivity and establishment of a suitable quality assessment process. ICT can also accelerate the educators’ training and facilitate invaluable communication and collaboration with their colleagues around the world, enabling them to draw examples of good practice from education institutions in the developed world.

Additionally, the application of ICT may drastically enhance the quality of graduates and stimulate collaboration and fruitful competition between top students from well established universities in the region. The job prospects for graduates may be improved, since the use of ICT will equip students with the desired skills for the local industry and provide them with a broader vision when tackling problems.

Technically qualified and experienced workforce will have a major impact on improving the country’s economy and growth. It is expected that in the long term the health and agricultural sector and the quantity of food products will be drastically improved; the capacity of the country to attract significant investments will be increased and this will result in an expansion in the industrial activities and the creation of job opportunities. Moreover, the exploration and rationalisation of the use of the
national energy resources and materials will be facilitated; this can lead to the development of products which will cover the national needs or may even be exported stimulating the country’s economy. A drastic improvement in the transport infrastructure may be achieved which will improve the use of the rural, urban and industrial areas. Finally, social and economic changes may be imposed which will strengthen the establishment of efficient governance.

In order to achieve these potential future objectives, it is essential for Afghanistan to develop and implement a rigorous and integrated national strategy on developing and managing a scientific educational system which can meet the 21st century needs and improve the quality of life of its residents.

References


Torsti Loikkanen
Knowledge and innovation are key drivers of socio-economic development worldwide regardless of specific development phases of countries or of their location. Competitiveness and welfare strategies of industrialised countries are based on knowledge and innovation and they upgrade innovation systems and policies accordingly. In the developing world many countries, especially large emerging economies have managed to alleviate poverty and improve welfare by investing in education, science, and innovation capabilities and institutions (hereafter STI). In numerous developing economies, however, the significance of STI and related policies for development is not well recognised and many less developed countries lack resources and expertise to set up STI. In these cases development assistance policies and funding as allocated to STI can contribute. Within this context the aim of this article is to give an overview on the role of STI for development, to STI in development aid, and to underlying analytical and practical approaches. The article first gives a short introduction on STI trends and strategies in developing countries vis-à-vis worldwide development. Second the article discusses different aspects of development aid like rationales of donors, effectiveness and impacts of aid, and integration of STI into aid policies with selected references to international and Finnish aid schemes. Among various public and private development aid (private philanthropic charitable donors, bilateral, and multilateral aid from international organisations) the article considers mainly bilateral aid. The article is based on the recent literature on the role of STI in development aid policy, and the article is intended to organize and support the outlining of VTT’s research agenda in innovation for development.

“We have a moral imperative to make science globally inclusive”

Irina Bogova, Director-General of UNESCO

UNESCO Science Report 2010
Introduction

Knowledge and innovation are key drivers in the global socio-economic development of all economies regardless of the specific socio-economic development phase countries are undergoing or of their location. Globalization itself is also a product of the knowledge-based economy and one of the ways new technologies reshape the economies of the third millennium (Thurow 2000). The structural shift of economies towards knowledge economies occur in different speeds and degrees in developed and developing economies. Competitiveness and welfare strategies of industrialised economies are based on knowledge and innovation and they develop innovation systems and policies accordingly. In the developing world many countries like large emerging economies have also applied STI based strategies and policies in alleviating poverty and improving welfare, and have attained significant progress. Especially large emerging economies China and India have been able to enhance welfare and gain growing economic and political power worldwide (e.g. Mashelkar 2008; von Zedtwitz 2008). The next emerging area is expected to be Africa with promising short- and long-term economic forecasts. Regions are also important for techno-economic development and innovations, and Ohmae predicts that region-states may even gradually replace nation-states thus making global competition among innovation systems all the more fierce (Ohmae 2005).

Along various manifestations of globalisation increases the awareness of the needs of science based solutions to grand socio-economic global challenges, such as climate change, health issues, pandemics, demographic change and ageing societies, food security, and availability of water and raw materials. Most seriously such problems as poverty, hunger, diseases, social exclusion, digital divide, environmental damages, and brain drain affect population in less developed world. The awareness of industrialised countries of the urgency to solve grand challenges also by science, technology and innovation programs is increasing. Grand challenges have a high priority for example in innovation policies of the European Union and in the Strategy for American Innovation (EC 2010, Strategy 2011). In the next RTD Framework Program the EU is moving from thematic R&D areas towards research of science and technology based solutions to grand challenges by thematic actions. The ultimate aim of global science and technology collaboration should indeed be in identifying and looking for science based innovative solutions to the acute needs and problems of less developed countries particularly.

As scientific challenges become continuously bigger and more global, it is impossible to pursue them without worldwide research cooperation. Accordingly also the EU promotes international scientific cooperation (ISC) to carry out better science and to pursue broader policy goals via scientific achievements (e.g. Siegler 2008). Besides the promotion of European competitiveness, among the strategic objectives of ISC are making worldwide scientific excellence available for Europe via circulation and not via brain-drain, to address specific problems on the basis of mutual interests and benefits with third countries or regions with European interests (for example, poverty-related diseases, environment issues, etc.), and addressing global scientific challenges, e.g. big science projects (fusion reactor, high-speed information networks, etc.). In many developing economies the significance of science and technology capacity and policies for development is not well recognised and less developed countries lack resources to set up corresponding infrastructures. In these cases different development aid funding schemes, as allocated to education, science, technology and innovation infrastructures, institutions and capabilities can accelerate the socio-economic development.

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For example, Roelof Horne, portfolio manager at Investec Asset Management, foresees Africa to be an area of sustainable high economic growth for the next two decades, due especially to demand from developing countries like China and India for what Africa has in abundance-energy, metals, and agricultural opportunities (Source: Nasdaq.com). Trade between China and Africa has been growing by an average of 30 percent a year over the past decade, and likely exceeded $100 billion in 2010 (Source: IMF 2010).
Within the context above this article examines science, technology and innovation and related policies (hereafter STI) in developing countries, the role of development assistance in the promotion of STI, and underlying analytical and practical approaches. STI driven development in the developing world has been increasingly recognized since the “the new phase of globalization” in early 2000s, and many scientific events have considered also this topic like, inter alia, the conference of Going Global: Challenges for Knowledge Based Economies in Helsinki in 2006 (Squicciarini and Loikkanen (Eds) 2008). Among the important recent contributions organizing and focusing the relevant research topics in this area are Lundvall et al. (Eds) (2009) and Kraemer-Mbula and Wamae (Eds.) (2010).

This article is structured as follows. Chapter 2 presents data of research and development in developing world vis-à-vis global data, introduces shortly to the debate of industrialization patterns in developing countries, inter alia also to Bottom of Pyramid approach which has received attention in recent years, and to various aspects of STI in developing countries. Chapter 3 describes current state, figures and various aspects of development assistance and STI, such as rationales, impacts and evaluation of aid and perceived trends in integrating STI to development aid. The article is based on the recent literature in STI and development assistance and on empirical observations of integration of STI in development assistance with selected references to Finnish development aid policy.

**Worldwide R&D and developing countries**

Chapter 2 gives a short overview on the selected STI input and output indicators on global level and in the developing world. The data is mainly based on UNESCO Science Report 2010.

The world devoted 1.7% of GDP to research and development (R&D) in 2007 (UNESCO 2010). The global annual budget devoted to R&D (Gross Expenditure to R&D) has exceeded one trillion US$, and was 1145.7 billion US$. Geographically 37.9% of global R&D was expended in North America, 32.2% in Asia, 27.4% in Europe, 3.0% in Latin America and the Caribbean, 1.6% in Oceania, and 0.9% in Africa. In Asia the share of Japan of global R&D was 12.9%, China 8.9%, and India 2.2%. In Latin America and the Caribbean the share of Brazil was 1.8%, and in Africa the share of South-Africa was 0.4%. In Europe the share of Germany of global R&D was 6.3%, of France 3.7% and of the UK 3.4%. In conclusion, Europe, Japan and the USA (the Triad) dominate R&D but are increasingly challenged by the emerging economies, above all by China (UNESCO 2010). Moreover, China and India, for example, are using their newfound economic power to invest in high-tech companies in Europe and elsewhere to acquire technological expertise overnight. Other large emerging economies like Brazil, Mexico, South Africa and Turkey are also spending increasingly in R&D.

The number of researchers worldwide was 7.2 million in 2007. China is on the way of overtaking the USA and the EU in terms of numbers of researchers, representing about 20% of the global stock of researchers. India represents only 2.2% of the worldwide total and Latin America and Africa 3.5% and 2.2% respectively. A migration of highly qualified researchers from South to North characterises past decade, and 20 million of 59 million migrants living in OECD countries were highly skilled (UNESCO 2010). Among the negative impacts of brain drain are reducing of total output, diminishing the competence of domestic high-skill sectors and eroding of tax base (Stiglitz and Charlton 2005).

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8 Figure 1 in Appendix shows global investment in R&D in absolute and relative terms for selected countries and regions, 2007.
The total volume of scientific publications worldwide was 986,099 in 2008, as counted by Thomson Reuters’ Science Citation Index, SCI (UNESCO 2010). The leading region in scientific publication is the EU, and USA is the leading single country in absolute terms. China’s share has more than doubled in six years and now represents more than 10% of the world total. Latin America’s share increased from 3.8% to 4.9%, thanks mostly to Brazil. Africa’s share of publications increased 25% between 2002 and 2008 and was 2.0% of the world total in 2008. Here, the rise was most noticeable in South Africa and the Maghreb but every African country saw the number of its articles recorded in the SCI progress. In the specialization of countries in scientific disciplines China have specialized in physics, chemistry, mathematics and engineering and technology but Africa and Brazil are strong in biology and India in chemistry.

As counted on a basis of the US Patents and Trademark Office (USPTO), European Patent Office and Japanese Patent), USA dominates the global patent statistics. As UNESCO (2010) concludes, this highlights the US technology market’s role as the world’s leading private market for technology licenses. Japan, Germany and the Republic of Korea are among other countries with the most patent-holders. India’s share is only 0.2% of all Triadic patents, a share comparable to that of Brazil (0.1%) and Russia (0.2%). The rest of the world barely accounts for 2% of the total stock of patents. Most of Africa, Asia and Latin America play no role at all. As UNESCO Science Report 2010 concludes, of all the indicators used in the UNESCO Science Report, it is the patent indicator which points most strikingly to the inequality of knowledge creation at the global level.

In addition to STI indicators UNESCO (2010) considers the number of Internet users telling how easier access to information and knowledge has provided opportunities for a more rapid diffusion of S&T. According to data BRIC countries and numerous developing countries are catching up quickly with the USA, Japan and major European countries for this indicator, and UNESCO (2010) assesses the rapid diffusion of Internet in the South to be one of the most promising new trends of this Millennium, as it is likely with bring about a greater convergence in access to S&T over time.

On the basis of STI and related indicators UNESCO (2010) draws, inter alia, the following conclusions of STI in the developing world. The disparity in development levels from one country and region to another remains striking, also in STI. The emerging countries like China, India and Brazil have initiated a new, three-way process of catching up simultaneously in the industrial, scientific and technological spheres. The increase in the ‘world knowledge’ stock by new digital technologies and discoveries in life sciences or nanotechnologies is creating fantastic opportunities for emerging nations to attain higher levels of social welfare and productivity. For example, in Bangladesh light engineering is producing import-substitution products creating employment and alleviating poverty, and in high-tech sector of pharmaceuticals the country is 97% self-sufficient and exports them to Europe.

UNESCO (2010) believes that it is the systemic ‘congruence’ between the various knowledge components of the innovation system that counts when it comes to devising a successful growth strategy. A growing emphasis in STI policy exists towards sustainability and green technologies, even in parts of the world not generally characterized by a large STI effort, e.g. in the Arab region and sub-Saharan Africa. Driven by concerns about climate change and environmental degradation, developing countries are attempting to monitor their territory more closely, often via North–South or South–South collaboration, as in the case of Brazil and China for the design of Earth observation satellites, or via projects like Kopernicus–Africa involving the African Union and European Union. UNESCO (2010) concludes that the globalizing trend affects research and innovation in various ways. It does not lead to

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9 Figure 2 in Appendix 1 describes scientific specialization of the Triad, BRIC countries and Africa in 2008.
a flat world and narrowed gaps in STI capabilities of countries and regions but to concentration of knowledge production and innovation emerging across a wider variety of countries.

**Drivers of industrialization, markets and STI in developing countries**

Chapter 3 introduces shortly to the debate of industrialization patterns in developing countries, among others to the Bottom of Pyramid approach which has received attention in recent years, and to various aspects of STI in developing countries.

**Development patterns and policies and STI**

Different patterns of industrialisation of developing countries have inspired different schools of thought in different scientific disciplines to develop various frameworks, models and approaches for understanding prerequisites, barriers and carriers of development. Since W. Arthur Lewis (1954), Paul Rosenstein-Rodan (1944) and Walt Rostow (1960) an abundant literature has emerged in development literature and e.g. Kraemer-Mbula and Wamae (2010b) is a short overview on earlier stages in this development, such as analyses of technology gaps and catching-up, and more recent concepts of innovation systems and social transformation. Among the relevant factors for development are resource endowments of countries, intervention vs. free market policies, related fiscal and monetary policies, saving rate and investments in physical and human capital, prioritising in agriculture policies vs. industrial sector policies, and so on. Growth depends much on foreign trade and foreign trade in turn on international trade rules, primarily on Doha trade-negotiation rounds of the World Trade Organization (WTO)\(^\text{10}\). Alternative policies are e.g. protecting national markets vs. promotion of foreign direct investments (FDI), embarking import substitution and infant industry policies, causing for example constraints of access to external markets (e.g. Stiglitz and Charlton 2005). Among the necessary conditions for success also in innovation led development are macro-policies stabilising general investment climate (e.g. Metcalfe and Ramlogan 2008)\(^\text{11}\).

An abundant literature exists of how and to which extent these various factors are hampering or contributing to economic development. Liberal market approach has its advocates (e.g. Easterley 2006). Sachs (2005) lists the following reasons in which countries fail to achieve economic growth: poverty itself as a cause of economic stagnation (lack of capital due for example an inability to saving), physical geography (e.g. landlocked regions due to mountain geography e.g. in countries like Bolivia, Ethiopia or Tibet), fiscal trap followed from corruption or e.g. from impossibility to taxation due to poverty, governance failures due e.g. to inadequate and unclear property rights, cultural barriers due for example to blocked societal role of women, geopolitics due to trade barriers or sanctions by foreign countries, lack of innovation due to lack of education, STI system and market incentives, and demographic trap, families having a large number of children for whom they cannot afford to organize education, nutrition, and health care services (Sachs 2005). On the basis of his analysis Sachs suggests a clinical economics approach pointing the way to a better strategy.

An important issue for the development is also the type of economic approach and markets which may be based on hands-on or on hands-off approach. For example according to Salinas et al. Mauritius, Rwanda and some other Sub-Saharan African countries, by achieving political stability and significantly liberalizing their economies, have experienced high growth in income per capita, while still maintaining specialization in natural resource exports. Stable macroeconomic development is important for being attractive to foreign direct investments (e.g. Kraemer-Mbula and Wamae 2010b).

\(^{10}\) See: [http://www.wto.org/english/tratop_e/dda_e/negotiations_summary_e.htm](http://www.wto.org/english/tratop_e/dda_e/negotiations_summary_e.htm).

\(^{11}\) The development may go also the other way around, i.e. good growth performance may allow countries to attain political stability or liberalize their economies (see Salinas et al 2011).
The recognition of the key role of STI for development in less developed countries as such has a long history. An important example is India where the architect of what India is today has been the first Prime Minister Jawaharlal Nehru. Nehru strongly believed in science and technology and he was convinced that “it is an inherent obligation of a great country like India, with its traditions of scholarship and original thinking and its great cultural heritage, to participate fully in the march of science, which is probably mankind’s greatest enterprise today” (Mashelkar 2008). In recent years innovation, market and entrepreneurship driven approaches, such as Bottom of the Pyramid and micro-financing, have gained advocacy during the 2000s (Salinas et al. 2011). In conclusion, as selected above indicate, there are a variety of different approaches in the analysis of growth and development patterns of countries and, moreover, an extensive on-going discussion of the drivers of growth in the development world as well.

Causes of poverty, informal economy and BOP markets

C.K. Prahalad analyses in The Fortune at the Bottom of Pyramid how market approach, private sector and innovations can be put at the centre of development as an engine of jobs and services for the poor (Prahalad 2005). The BOP market is huge from 4 – 5 billion underserved people with various needs of the poor. As Prahalad accentuates, to participate in these markets traditional products, services and management will not work, but private sector must learn to innovate to make product and services affordable to people. He seems there are tremendous benefits to multi-national companies who choose to serve these markets in ways responsive to their needs. He predicts the poor of today become the middle-class of tomorrow. There are also poverty reducing benefits if multi-nationals work with civil society organizations and local governments to create new local business models.

We do not consider below the whole BOP approach and related controversy but concentrate shortly on the arguments of Prahalad related to the background of poverty in which earlier work of Do Soto (2000) plays an important role. In The Fortune at the Bottom of Pyramid Prahalad suggests that businesses, governments and development aid donors stop thinking of the poor as victims and start considering them as resilient and creative entrepreneurs and as value-demanding consumers. He analyses the background of poverty by asking Are the Poor Poor? Prahalad starts from the following core assumptions in thinking on poverty reduction and development assistance during the 30 past years: (1) Poor countries are poor because they lack resources, and aid is seen as a substitute for locally generated resources; (2) aid from rich countries to the governments of poor countries for specific projects would reduce poverty; (3) investments in health and education might have largest multipliers per dollar of investment in development and hence aid must be skewed to these sectors; (4) the record of aid and loans from various bilateral and multilateral donors is at best mixed and development community is recently paying attention to the role of private sector in building markets (Prahalad 2005). Among the very few voices of dissent to this dominant logic in development community has been De Soto (2000).

De Soto argues that poor countries are poor due to the fact that they are often asset-rich but capital-poor (De Soto 2000). Assets cannot become capital unless the country guarantees a rule of law whereby the ownership of assets is clear and because of clear legal title assets can be sold, bought, mitigated, or converted into other assets. It is the legal ownership that converts assets into capital. De Soto demonstrated that the trapped resources, assets that cannot be converted into capital because of underdeveloped legal framework and institutions, can be significant. This perspective suggests that poverty is at least partially self-imposed problem in most of the world.
On a basis of De Soto’s arguments Prahalad draws the following conclusions: (1) All forms of foreign investment in poor countries (aid, FDI by MNEs, philanthropy) are only a fraction of the potential for capital which is trapped in these countries; (2) In the absence of enforceable contract law local commerce is conducted by a vibrant extralegal of informal sector (or black market), which is the primary face of the private sector in most developing countries. Firms in informal sector are unable to grow because they cannot attract capital, and remain small, local and often inefficient; (3) There are contract systems that are local; each slum might have its own unwritten but clearly understood rules, the enforcement of which might be the privilege of local “strongmen”.

To conclude, if we consider trapped assets, poor countries could be quite differently rich as compared to current situation. They might have vibrant market economy and private sector although it is informal, fragmented and local. As Prahalad concludes, the problems with trapped assets in many developing countries are aggravated by inefficient systems and management, poor legal structures, and enforcement mechanisms of laws, etc. One of the conclusions is that the need creates a transparent market for capital, land, labour, commodities and knowledge. For reducing corruption Prahalad calls for clearly developed laws, transparent micro-regulations, social norms, and timely and uniform enforcement of all parts of transaction governance capacity.

Prahalad’s approach has led to extensive debate of BOP opportunities. For example Karnani (2007) argued that there is no fortune at the bottom of the pyramid and that for most multinational companies the market is actually very small. He suggests that the only way to alleviate poverty is to focus on the poor as producers rather than as a market of consumers. Prahalad provided a multi-page response to Karnani’s article (Prahalad 2006). In conclusion, around BOP concept has emerged many activities promoting community or grass root innovations. Moreover conclusions of De Soto, especially with respect to informal economy and informal sector are both relevant and analysed increasingly in the context of innovation for development (see e.g. Lundvall et al. 2009b; Kraemer-Mbula and Wamae (Eds.) 2010; Kraemer-Mbula and Wamae (2010a, 2010b). Kraemer-Mbula and Wamae (2010b) gives an in-depth introduction to the definition and empirical data of informal sector in Sub-Saharan Africa.

Towards innovation system thinking

An awareness of the role of STI in developing countries in alleviating poverty and enhancing welfare is growing (e.g. UNESCO 2010). In principle the role of STI in developing and developed countries does not differ: the primary role of STI is to contribute to the welfare of citizens. In less developed countries the most severe problems are due to poverty, and require STI based solutions in challenges posed by hunger, diseases like malaria and HIV, child mortality, and environmental damages. Also such relatively new approaches as open innovation and demand-led innovation can contribute to innovation also in developing countries (von Hippel 2005; Chesbrough 2006; Kraemer-Mbula and Wamae 2010b). For example, Kogut and Metiu (2001) argue that because open source works in a distributed environment, it presents an opportunity for developing countries to participate in frontier innovation (2001). It is important to note however that demand in many developing countries is shaped by informal economy (Kraemer-Mbula and Wamae 2010c).

A specific analysis of innovation systems, institutions and policies of education, science and innovation policies is still a relatively recent topic in the agenda of developing countries and also in scientific analysis of development patterns. Among the recent research contributions in this field are for example Chaminade et al (2009), Lundvall et al. (2009b), among the overview on the area is
Kraemer-Mbula and Wamae (Eds.) (2010), and UNESCO (2010) gives abundant data and analysis in this field. On a basis of OECD-UNESCO workshop in 2009 OECD concludes that there will be too little innovation and entrepreneurship in developing countries in the absence of major public support through institutions, policies and programmes, and services. Accordingly it is of strategic importance to get innovation, wherever it occurs, onto the development agenda and into public policy and programming (Kraemer-Mbula and Wamae (Eds) 2010). In spite of hesitations by some developing economists, innovation driven approach proves to get increasing support among policy makers and research community analysing STI for development\(^\text{12}\).

**Contribution of STI for development**

How is contribution of STI on development? The analysis by Knowledge Economy Index (KEI) by the Knowledge Assessment Methodology (KAM) of the World Bank supports the hypothesis that strong correlations exist between knowledge related investments and economic growth regardless of the development level considered (Aubert 2008). The growth rates of China and India are considered as interesting examples of knowledge driven development and, as UNESCO (2010) concludes, we seem to be on the verge of a structural break in the pattern of knowledge contribution to growth at the level of the global economy (UNESCO 2010, Mashelkar 2008) but interesting examples exist also among smaller economies. For example, knowledge driven development has encouraged Malaysia to apply a long-term strategy to leapfrog from primary production and manufacturing into knowledge economy (e.g. Jarjis 2008).

**Economic and STI capacities of developing countries**

There are thorough differences in economic and institutional systems of countries in different development stages, and any general STI model and policies does not fit to all countries. Hence STI in different countries needs diverse analyses and case studies respectively (e.g. Gault and Zhang 2010). Differences of developing countries are due inter alia to the extensive informal economy or informal sector (Kraemer-Mbula and Wamae 2010 (Eds.); Prahalad 2005). Informal sector has effects on policy-making and to planning, implementation and evaluation of STI. Sachs analyses developed and developing economies by classifying them as low-, middle- and high-income countries with a population of at least two million on a basis of the World Bank data between 1980 and 2000 (Sachs 2005). Twenty-five developing countries proved to have negative growth and biggest problems with economic decline was in Sub-Saharan Africa countries and other poorest nations (since that the situation has changed). Sachs concludes that among most important determinants of success stories of development countries is food productivity. Among the explanations is Asia, unlike in Africa, is that donor agencies have given ample support to the development of new high-yield varieties (Sachs 2005).

One way is to classify countries and regions according to their economic strengths and science and technology capacities as follows (Figure 1).

\(^{12}\) On this discussion see e.g. Lundvall et al. (2009b).
Figure 1. A classification of countries and regions according to their economic strengths and science and technology capacities\textsuperscript{13}.

The most urgent is to find the ways to improve the situation of majority of African countries and those South-East Asian countries in which both economic level and STI level is lowest. In South and East Asian and South American big emerging countries the STI systems are relatively well developed and economic growth creates new resources for their further enhancement\textsuperscript{14}. Many Arabian economies have been strong economically due especially to large oil reserves and exports\textsuperscript{15}. Social and economic welfare development in many of these economies has however been slow or neglected which has recently led to political restlessness in the area.

\textit{Innovation systems in developing countries}

Innovation system is often used as a framework in describing and analysing the role of STI in developed and increasingly also in developing economies (e.g. Kraemer-Mbula and Wamae 2010 (Eds.); Lundvall et al. (Eds.) 2009; Metcalfe and Ramlogan 2008). Figure 2 is a simplified illustration of main components of national innovation system in industrialized countries.

\textsuperscript{13} The figure is outlined by Dr. R.R. Mashelkar, former Director of CSIR India, and Chairman of the Board of Global Research Alliance (GRA), during a personal discussion with the corresponding author of this article.

\textsuperscript{14} In this context Dr. R.R. Mashelkar cites Jack Welch, former CEO of General Electric, who in the inaugurating speech of The Jack Welch R&D Centre in Bangalore said that “India is a developing country, but it is a developed country as far as its intellectual infrastructure is concerned. We get the highest intellectual capital for dollar here.” (Mashelkar 2008).

\textsuperscript{15} With some at least timely exceptions like Saudi-Arabia in 1980-2000 according to Sachs’s calculations based on World Bank data (Sachs 2005). Also in general in many oil-rich countries the economies seem to rise and fall with the price of oil.
An attempt to apply the framework of Figure 2 in developing countries, especially in less developed countries, reveals essential challenges: due to dominant role of informal sector in the economy many key institutional preconditions for the system are undeveloped or missing, such as developed markets and market based demand due to extensive informal sector, and research and education system, STI infrastructure with e.g. venture capital and IPR system, or intermediate organisations like public research and technology organisations. Also many framework conditions like financial environments, literacy, taxation and incentives, are undeveloped in many less developed economies. As the analysis of Kraemer-Mbula and Wamae indicates, when analysing informal sector, even surprisingly many aspects of informal sector, such as demand driven innovation, skills in informal sector, participation in value chains, the role of intermediary organisation, are seen however relevant and can be integrated into the analysis of innovation for development (Kraemer-Mbula and Wamae 2010b). The main arising conclusion is that our current knowledge of these links is very scarce and shall be examined carefully in the future in order to understand also their relevance to policy-making for promoting innovation for development.

Due to specific conditions of each developing economies also innovation system frameworks shall be adapted in such a way that take into account structural specific conditions of each country. Metcalfe and Ramlogan argue that the instituted frame in relation to the growth and development of economic capability and its associated knowledge base are central to the development problem by capturing the fundamental point that economies only develop through their people becoming more knowledgeable (Metcalfe and Ramlogan 2008).

The development of STI institutions and infrastructure require long-term strategy and global collaboration. For example, although the role of science and technology for socio-economic development was understood in India as early as 1947 when India became independent, the development was accelerated since 1991 when the economy and markets opened up internationally (Mashelkar 2008). Such a strategy requires infrastructure and framework conditions such as markets and market incentives of innovation, innovation policy institutions, including the provision of an independent judiciary and property rights, a functioning financial system, an adequate and affordable higher education system, an ICT infrastructure, as well as roads, ports and transport and storage services.
The role of STI infrastructure is necessary for absorptive capacity of any relevant international knowledge whether it is in the form of FDI or any other knowledge (e.g. Navarretti and Venables 2004). In conclusion, framework conditions for innovation shall be on the agenda of STI development in developing countries and on the agenda of development assistance of donor countries and international donor organisations.

**Brain drain among main challenges**

Among the main challenges for developing economies is brain drain, often benefitting developed countries but hampering STI progress in less developed countries e.g. by reducing total output, diminishing competence of domestic high-skill sectors, and eroding then tax base (Stiglitz and Charlton 2005; Weinberg 2011). For example, according to Naim (2011) internationally recognized Aga Khan Hospital University in Karachi, Pakistan trains approximately 100 graduates each year at a cost of US$84,000 per graduate, and even almost 99.9 percent students immigrate to USA after graduation (Naim 2011). Brain drain is not only external but also internal. For example internal brain drain emerges when domestic firms cannot compete with the attractive compensation packages offered to personnel by foreign firms based in India (UNESCO 2010). One related aspect is remittances from workers in developed countries. They are an economically significant transfer to less developed countries (e.g. Stiglitz and Charlton 2005; CGP 2010).

**International STI collaboration**

As Stiglitz points out, knowledge is not only a public good but a global public good which is central to successful development (1999), and consequently international scientific cooperation is necessary and beneficial for all scientific science and technology communities worldwide. As Georghiou concludes, the flow of knowledge across national boundaries is among key issues of a modern innovation processes and R&D cooperation is an important factor in the discovery, application, and diffusion of knowledge, increasingly exceeding national borders (Georghiou 1998). The geography of global STI is in change, STI is internationalizing and researchers are increasingly uniting their efforts for the benefit of global society and developing countries. One example of global research collaboration networks is Global Research Alliance, a joint R&D effort by research and technology organisations (RTOs) of CSIR (India),CSIRO (Australia), CSIR (South Africa), VTT (Finland), DII (Denmark), TNO (Netherlands), SIR (Malaysia), FGG (Germany) and Battelle (USA). The aim is to use the global talent pool to great global good through global funding (Mashelkar 2008).

**Rationale and impacts of STI in development assistance**

In many developing economies the significance of STI and related policies for development is not well recognised and many less developed countries lack resources and expertise to set up STI systems. In these cases development assistance policies and funding, as allocated to STI, can give an essential contribution. Development aid has a long history and, as Jayaraman and Kanbur (1999) point out, both public discourse and debate on foreign aid have undergone an interesting transformation especially since the fall of the Berlin wall. In the Cold War period the rationale for foreign aid was security or solidarity, and official flows, military assistance and flows for development purposes, helped keep countries in one of the two main global blocs. Moreover there was a strong sentiment in industrial countries that resource transfers from rich to poor countries were a moral obligation, and these two influences together led to high and increasing aid flows (Jayaraman and Kanbur 1999). Today “the Cold War rationale” has disappeared, and “aid fatigue” has gripped the other major rationale, i.e. the result of budget pressures in donor countries and considerable scepticism about the efficacy of foreign aid in helping poor countries, particularly the poor (ibid.). In single developed
economies the development aid has followed the international trends but, as a national learning process, with certain national peculiarities as the overview of Ainamo et al. (2009) indicates in the case of Finland.

In recent decades the role of development aid has been implemented according to various strategies and targets, and examined within different frameworks and contexts, as for example within information society, knowledge economy, global public goods, and more recently, also within science and innovation systems. In the development studies the rationale, role and short and long term impacts of development assistance schemes have been among key research topics, and the content and analysis of impacts and effectiveness of development aid depends also from the analytical approaches and frameworks applied. For example Kaul et al (1999) apply undersupply of global public goods, externalities and related economic analysis as a framework in the analysis of searching for solutions to the main challenges of the development world via international collaboration and development aid. Sachs (2005) analyses different factors impeding economic growth, among them also governance failures and lack of innovation, and draws conclusions of the role of development assistance. Stiglitz (2002), within a context of the globalisation phenomenon, explores the reform needs of international development aid policies and procedures.

Chapter 4 discusses the role of science technology and innovation in development assistance policies and schemes (hereafter DA). Section 4.1 introduces to recent trends, figures of development aid and, in order to give a comprehensive scope to development aid, also data of other forms of aid like private charity and philanthropy funding. Section 4.2 discusses targets, rationales and impacts of development aid with some references to Finnish development policy documents. Section 4.3 reviews current trends in the integration of STI and development aid.

Recent trends and figures of DA

The OECD compiles regularly Official Development Assistance (ODA) funding of international bilateral or multilateral aid institutions (OECD 2011). The OECD figures show continuing growth in DA in 2009 despite the financial crisis (OECD 2010a). In 2009 most of USD 119.60 billion of Official Development Assistance (ODA/OECD) was from 23 members of Development Assistance Committee (DAC/OECD). The largest DAC are the US (USD 28.67bil.), France ($12.43 bil.), Germany ($11.98 bil.), UK ($11.50 bil.) and Japan ($9.48 bil.). None of these countries however met the UN target of 0.7 percent of GNI as aid\(^\text{16}\). The only countries meeting UN target of 0.7 percent of GDI as aid in 2009 were Sweden (1.12%), Norway (1.06%), Luxembourg (1.01%), Denmark (both 0.88%) and the Netherlands (0.82). Net ODA from the European Union was 9654 million euro in 2009, and the Finnish net ODA 1.29 Billion Euros and 0.54% of Gross National Income\(^\text{17}\).

### Finland's official development assistance 2011

Finland is committed to reach the 0.51% minimum figure set by the European Council in 2005 for the EU-15 by 2010, and to reach 0.7% by 2015. In 2011 Finland’s official development assistance appropriations will be 10746 million euro of which the actual development cooperation is 844 million euro (via the Ministry for Foreign


\(^\text{17}\) Appendix 4 gives figures of Net Official Development Assistance (NOA) disbursement of Finland 2008-2009.
Affairs, MFA), other ODA is 239 million euro (MFA development cooperation administration, costs of refugee reception, share of the EU's development budget, disbursements to other international organisations). Finnish DA appropriations will be 0.58% of GNI in 2011 which is in per capita terms 200 euro per capita. The actual development cooperation will be 157 euro per capita. The appropriations of actual development cooperation (DC) administered by MFA are allocated to nine budget lines, multilateral DC, country- and region-specific DC, European Development Fund, non-country specific DC, humanitarian aid, planning, support functions and development information, evaluation and internal audit of DC, support to NGO DC, and interest subsidies. The allocation of appropriations is guided by the Government’s development policy programme adopted in 2007. The eradication of poverty and ecologically sustainable development are the most important objectives of Finland’s development cooperation according to the Millennium Development Goals agreed jointly in the United Nations.


The point of departure in considering the rationale of development aid is the need of aid in the developing world. The need of aid raises also the question on the current level of aid - how is the aid level now as compared to the identified needs of aid. In the UN Millennium Project an extensive assessments and corresponding detailed calculations have been made of the needs of global development aid till 2015 (UN 2005). Although there is not any high degree of precision of these estimates, the target of the level of the net official development aid in 2015 is assessed to be increased to 195 US billion dollars (Sachs 2005). As Sachs (2005) concludes, this would be require an increase of 0.44 to 0.54 percent of the rich-world gross national product (GNP) each year during the forthcoming decade. This is significantly less than the 0.7 percent of GNP, as promised in official development assistance already in early 1970s.

An ordinary debate of development assistance concentrates often on bilateral or multilateral aid donor funding. As Desai and Kharas conclude, the nature of development assistance is however changing and new delivery mechanisms and new players are becoming important parts of the aid system and bypass the traditional channels (Desai and Kharas 2010). New players from the private sector include for example foundations, religious organizations, other NGOs and nonprofits, as well as individual philanthropists. Table 1 presents the recent data collected by the World Bank of the resource flows including foreign direct investments (FDI), remittances to developing countries, Official Development Aid (ODA), and private debt and portfolio equity.

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18 Over the past 35 years the members of the UN have committed to 0.7% of rich-countries' gross national product (GNI) to official development assistance. The commitment was first made by the UN General Assembly in 1970.
Figure 1. Resource flows, including FDI, remittances to developing countries, ODA, and private debt and portfolio equity. (Sources: World Development Indicators database and World Bank Migration and Remittances Unit. Private debt includes only medium- and long-term debt. FDI = foreign direct investment; ODA = official development assistance; — = not available.)

Desai and Kharas in their analysis of recent trends in private and NGO philanthropy donor funding conclude inter alia that online philanthropy has proliferated with the spread of global internet usage (Desai and Kharas 2010). Private aid comprising of foundations, non-governmental organizations, religious groups, and charities contributed for example in the United States almost $37 billion to development causes in 2007 when for example The World Bank committed about $25 billion.

**STI and targets and rationales of development aid**

The starting point for the consideration of the role of science, technology and innovation, and related policies (STI) in development assistance is the growing role of STI for the development of any countries regardless of their development phases or of their location in global geography. This is well recognized also by main international organizations such as the OECD, UN organisations, as well as by individual countries granting development aid. For example according to the OECD the turbulence created by the 2008-09 economic and financial crisis give innovation even more immediate importance as a contributor to growth, poverty reduction and social cohesion (Executive Summary in: Kraemer-Mbula and Wamae (Eds) 2010). However, as Chaminade et al. point out (2009), it is impossible to identify innovation policies that would apply to all developing countries. Policies able to support innovation in a developing country require the willingness of its government to experiment with policy in order to find the solution that best fits their needs. Development assistance agencies should support this type of policy learning. These issues are also addressed in Lundvall et al. (2009), a study that complements this one.”

**Philanthropy and human development as motivations of aid**

Behind the basic motivations of development aid are the various needs of aid in the developing world, as identified for example in the UN Millennium Project or in development policies of donor countries, and the philanthropy and charity of donors. Public development aid is tax based funding from donor countries allocated directly to target development countries or indirectly via international organisations like UNDP. Public development aid is related to political decision-making and
consequent alternative targets in the use of public resources. Ultimately the legitimacy of development aid is based on the empirical evidence of the socio-economic impact of aid, as indicated by evaluations and quantitative and qualitative impact assessment studies. In precise, legitimacy is proved by the added benefit of development aid as compared to situation without aid. Impacts of development aid can be physical, economic, and cognitive and may relate to changes in behaviour and performance that would not have occurred without aid. A continuous debate exists of impacts and effectiveness of public development aid, its legitimacy, and development needs arising from impacts and evaluations of DA (OECD 2010b). This section considers targets, objectives, motivations and legitimacy of public DA with some references also to other forms of development aid like private charity.

The general motivation of development policies and aid is based on philanthropy and the promotion of human development. Sen defines human development as “advancing the richness of human life, rather than the richness of the economy in which human beings live”. Hardin and Wantchekon accentuate that human development is about giving people choices; it is about allowing them to lead long and healthy lives, to acquire knowledge, and to gain access to the resources necessary for a decent standard of living (Hardin and Wantchekon 2010). When becoming a member of the United Nations the country commits to altruistic principles of the UN. The most extensive global human development action plan is Millennium Declaration of the United Nations intended to achieve the eight anti-poverty goals by 2015. In the Millennium Declaration the General Assembly reaffirms its faith in the Organization and its Charter as indispensable foundations of a more peaceful, prosperous and just world, and a collective responsibility to uphold the principles of human dignity, equality and equity at the global level. UN Millennium Project made recommendation of global donor funding of 7 billion USD to R&D needs for health, agriculture, energy, climate, water and biodiversity conservation in the poorest countries.

### Finland’s development policy: Towards a sustainable and fair humanity policy

Development policy is an integral part of Finland’s foreign and security policy. Development policy contributes to the global effort to eradicate poverty through economically, socially and ecologically sustainable development.

The main goal of development policy is to eradicate poverty and to promote sustainable development in accordance with the UN Millennium Development Goals which were set in 2000.

Finland places particular emphasis on the importance of issues relating to climate and the environment. At the same time, we stress crisis prevention and support for peace processes as an important element of the promotion of socially sustainable development.

Development cooperation is a key instrument of development policy. It can be used to promote the strengthening of an enabling environment for development in the poorest countries in order to improve the preconditions for investment and trade and to achieve economic growth.

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Development cooperation is not the only policy sector that generates development policy impacts but, for example, trade policy also plays a role. The industrial countries’ obligation to change their production and consumption habits in an ecologically sustainable direction is also one form of development policy.

Finland’s development policy is steered by the government resolution on development policy from October 2007.


Humanitarian aspects are also accentuated in national development aid programs. For example the U.S. document `USAID Primer: What We Do and How We Do It´ informs to be a binding document that describes the context of development or humanitarian challenges, states and justifies USAID’s approach to them, and gives specific guidelines that must be followed in designing and implementing USAID programs addressing the challenges. A policy also communicates USAID’s priorities and approaches to other U.S. government agencies, donors, implementing partners, and others (www.usaid.gov). Also the principles of private charity donors, such as Bill and Melinda Gates Foundation, are based on beliefs of the role of philanthropy. According to Guiding Principles of Gates foundation “we demand ethical behaviour of ourselves”, and “science and technology have great potential to improve lives around the world” (http://www.gatesfoundation.org). An extensive research into AIDS is among different areas funded by Bill and Melinda Gates Foundation.

Market and government failures as rationales for aid

In the economic analysis of development aid the conventional framework consists of public goods, market failures and system failures and related economic rationale for aid. As Cook and Sachs argue, likewise market failure gives a reason to public sector intervention in general, DA assistance should have a similar focus, supporting desirable activities that will not be provided adequately either by private markets or by local and national governments that are recipients of such aid (1999). Kaul et al (1999) is a representative collection of articles dealing with global public goods and market failures. The framework conditions for innovation vary essentially in developing countries from industrialized countries. As Gault and Zhang (2010) note, the developing countries, especially the least developed, may not have a functioning market or all of the institutions that constitute or support an innovation system in a developed country. In the innovation policy analysis market failure analysis is completed by system and policy failures (e.g. Metcalfe 1995; Woolthuis et al. 2005). For example Sachs (2005) and Cook and Sachs (1999) analyse the importance of government failures (2005). According to Cook and Sachs in aid programmes in the 1980s and 1990s the basic motivation was that national governments could not be trusted to provide public goods within their own territories as a result of some kind of “political failure” (1999).

Needs of integrated development and STI policies

The promotion of innovation for STI requires horizontal approach through all policy administrations, especially between ministries of foreign affairs, employment and economy and education and culture. As Gault and Zhang (2010) accentuate, this concerns both target and donor countries of DA. In donor countries innovation policies should be taken into consideration in order to ensure that all government policies with a direct or indirect impact on development are coherent. In developing countries co-ordination between agencies and policies is needed to ensure that the impact
of innovation for development is maximised (Gault and Zhang, 2010). The Finnish Development policy programme (Formin 2007).

For example, Japan is undertaking initiatives to enhance co-ordination, for example, between the development assistance agency JICA and Japan’s science and technology funding agency, JST, in order to implement jointly co-operative research projects between research institutions in Japan and in developing countries (Gault and Zhang 2010). Japan is also supporting a research project carried out by the OECD Global Science Forum to identify good practices in international research co-operation between developed and developing countries. In Finland innovation related issues have been on development assistance for 2-3 years and in the OECD especially since 200921. Among the new development policy instruments of MFA is Institutional Cooperation Instrument (ICI) the objective of which is to strengthen the capacity of public sector institutions, whether in the area of innovation policies or any other areas, in partner countries by utilising the expertise that can be found in the Finnish public sector. The idea is that capacity can be best enhanced with the help of colleagues - civil servants from a respective organisation with similar tasks and responsibilities22.

Role of private sector in development aid

Development policies and aid has been primarily collaboration between public sector organisations from both receiving and donor countries. In the context of innovation private sector plays however an important role, for example, with respect to private incentives to innovation, commercialization of innovation, etc. Kraemer-Mbula and Wamae (2010b), while accentuating the importance of commercialisation of knowledge and related importance of private sector, recognize that placing the private sector on the donor assistance agenda raises a fundamental question with regard to the general principle of limiting the benefits that may accrue to the donor while maximising those intended for the beneficiary. Kraemer-Mbula and Wamae note, this may be construed as shifting attention from the public sector, which is thought to be better placed to ensure equitable distribution (2010b). Kraemer-Mbula and Wamae conclude that perhaps it is not too early to make better attempts at integrating market demands into the relationships between donors and developing countries. This may involve some rethinking of the general principle or, to put it more bluntly, of the reciprocal knowledge benefits of donor assistance. Kraemer-Mbula and Wamae also give several examples in international collaboration in research and innovation between donor countries and developing countries with the private sector.

Evaluation and impact assessment of development aid

Ultimately the legitimacy of development aid is given by empirically proven impacts and effectiveness of aid, as indicated by evaluation and impact assessment exercises. Empirical data of DA impacts and effectiveness supports the legitimacy of DA and acceptance among donors and among policy-makers and politicians making decisions of aid. The role of evaluation and impact assessment is increasing due to growing pressure on aid budgets and various new approaches in development aid and especially due to needs of accountability, management and learning structures of development agencies. A hot controversy has continued about the legitimacy and impacts of DA since decades (e.g. Hancock 1989; Easterly 2007).

22 Source: http://formin.finland.fi/public/default.aspx?contentId=132197&nodeId=40157&contentlan=2&culture=en-US.
Perhaps the most visible controversy of impacts and legitimacy of development aid has been related to aid policies of international organisations World Bank (WB) and International Monetary Fund (IMF) (Hancock 1989; Stiglitz 2002; Easterley 2006, 2007). One of the key issues in this debate has been the requirement to aid receiving countries to meet a large number of conditions. For example a country must quickly pass a piece of legislation of reform social security, bankruptcy, other other financial system if it is to receive aid (Stiglitz 2007). Excessive conditionality was one of the major complaints against the IMF and the World Bank, and, as Stiglitz concluded (2007), both institutions have admitted that they went overboard, and have actually greatly reduced conditionality (Stiglitz 2007).

In the evaluation of development assistance aid agencies apply currently the principles of the Paris Declaration and of Accra Agenda for Action in the ownership, alignment, harmonization, and managing for results and mutual accountability. OECD executed in 2010 a stocktaking study of how the evaluation function is managed and resourced in development agencies and what are the identified major trends and challenges of evaluation (OECD 2010b). The study concludes inter alia that evaluation is changing and moving away from project outputs to assess broader impacts of development assistance. Evaluation is adapting to new aid modalities and cross-cutting issues, and involving increasingly country partners. The study also points to several areas where development agencies could do more to meet their commitments on mutual accountability and partner country ownership. The study also sets out several areas to be further explored through joint effort, including communicating and supporting the use of evaluation results (OECD 2010b). As directed increasingly to set up and enhance STI infrastructures of developing countries, development aid schemes bring new challenges also to evaluation and impact assessment of DA.

Needs of coordination and collaboration in global public policy and development aid

Many developing countries lack resources and expertise to set up STI infrastructure and then different sources and forms of development aid can be of welcome help. In the context of this article two questions arise about development assistance: How are the recent overall trends in development assistance, and, in particular, how far and in which ways DA can contributes to STI in developing economies? The nature of development assistance is changing, with new delivery mechanisms and new players becoming important parts of the aid. New players from the private sector include for example foundations, religious organizations, other NGOs and nonprofits, as well as individual philanthropists system, and these may challenge and bypass the traditional DA channels (e.g. Desai and Kharas 2010).

The role of STI for socio-economic development is not well recognised in the development agenda of developing countries but also not by donors, and there is an urgent need to put innovation on the development agenda to promote co-operation between developed and developing countries to achieve this (Gault and Zhang 2010). This calls also for greater evidence-based advocacy for the important role of STI, and international organisations such as the OECD, the World Bank and the like are well placed to play a facilitating role in this action area (ibid.). The number of various multilateral and bilateral donors has arisen as another challenge in development aid and the needs of coordination of global official development assistance (ODA) policy is increasingly discussed recently. Within a framework of global public goods and needs of global policy Severino and Ray call for collective action a ‘hypercollective action’ aiming at making aid programs more effective and (2010). Also the Finnish Development Policy Program calls for increased cooperation and

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coordination between all donors in international development policy which will prevent overlapping functions and increase coherence (Formin 2007).

Conclusions

Chapter 4 discusses recent trends of development aid and in the context of other forms of aid, the rationales of aid and the integration of STI and development aid. The nature of aid is changing and new players are becoming parts of the global aid system. Along increasing number of players there are also increasing financing rationales and methods for development aid. Moreover, increasing arising challenge, due to a growing number of players, is the increasing need of global coordination and collaboration - a `hypercollective action´ - in development aid policies and schemes in order to avoid overlapping and making the global development aid policy more effective and efficient.

Conclusions, policy implications and research agenda

Science, technology and innovation and related policies in developing countries are in a change due to penetrating impacts of science and innovation in socio-economic development. Developing countries recognize increasingly science and innovation as key potentials for eradication of poverty and enhancing the welfare. While many low income developing economies lack resources for setting up STI system and infrastructure, development aid schemes can contribute, when allocated to education, science and innovation. The traditional development assistance mode is also challenged by increasing number of different donors and donor communities such as private charitable donors, online philanthropy via global internet usage, increasing activities of emerging economies in the developing world, and so on. These trends challenge also the rationale of public development aid policies and raise also increasing needs for a coordination and collaboration of global development assistance system. Accordingly, radical changes are needed in development aid policies in the future. This is especially true for the small open economies such as Finland having limited financial resources.

This article gives an overview on the role of science, technology and innovation for socio-economic development in the developing world, on the role of STI in development aid, and on underlying analytical and practical approaches. The article intends to support and organize the outlining of VTT’s research agenda in the innovation for development. Among others the following conclusions and implications for the future work arise on a basis of the article.

Innovation for development

Different developing countries are in different phases in the development of innovations, innovation systems and STI policies. The economic and industrial structure may be diverse consisting both manufacturing or especially in case of less developed economies mainly primary production. Arising research needs are the role of grass-root, community and other types of innovations in local, regional and national environments and also the dynamics of industrialization patterns based on innovations. Our understanding is limited of the models and concepts of local, regional and national innovation systems, and their mutual relationships in developing economies, and in this context it is important to examine also the nature and innovation aspects and capacities of informal sector in less developed economies. Existing modes and development needs of absorptive capacities are of importance in order to utilize different forms of international knowledge and technology transfer like FDI or various development aid schemes. Studies of carriers and barriers of the markets at the Bottom of Pyramid and micro-financing are of increasing relevance as well. We need also the research of the roles and importance of such challenges as brain drain, brain circulation, and the ways of benefitting from intellectual Diaspora reserves and remittance. An in-depth understanding of these and many

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related topics is relevant for making evidence based STI policies for eradicating poverty and enhancing the welfare of citizens´ in the developing countries.

**STI policies and development aid**

Among the topics in the research agenda of the policies in science, technology and innovation are the motivations, legitimacy and rationale of development aid. In order to be able to assess the performance of aid also performance indicators and impact assessment methodologies of aid programs shall be further developed. Successful aid policies require also horizontal coordination and collaboration especially between education, science and innovation policies, economic policies and other relevant policy areas. Reciprocal expertise utilisation and collaboration is needed between policy administrations both in donor and also in aid receiving countries, in donor countries particularly between ministries and agencies responsible for development aid and science and innovation, and in developing economies between ministries and agencies responsible for education, science and technology and those responsible for the economic development. While innovation by definition is a future oriented concept, such innovation policy tools as foresight and roadmaps of the socio-economic potential of the development can support the future planning and implementation of STI driven policies in developing economies.

Development aid is a learning process which follows general socio-economic and technological trends, such as a global shift towards science, technology and innovation driven economies and policies indicates. Development aid policy is towards innovation for development and novel approaches like market driven activities based on bottom of pyramid approach and micro-financing can be integrated also into development aid schemes. In developing countries the encouragement and incentives to innovation can be promoted also by organising reward competition in innovation. For example in India the National Innovation Foundation has so far conducted five National Award Functions and given away hundreds of awards in various categories in its nationwide innovation movement. (cf. [http://www.nif.org.in/](http://www.nif.org.in/)).

Principles and initiatives of corporate social responsibility (CSR) as suggested by Global Reporting Initiative (GRI), Global Compact initiative by the United Nations, and the recent International Standard ISO 26000, Guidance on social responsibility, shall be considered as important international criteria and guidance in development aid policies. Aid policies shall be planned and executed in close public-private partnerships, and the expertise of private sector can be utilized in commercialization and other market related stages of innovation processes. Various global coordination procedures have to be developed for global public goods and DA policies, as argued by Severino and Ray (2010).

In conclusion, science, technology and innovation for development is an extensive area both in practical terms and as research topic. This article is an attempt to organize and outline VTT’s research agenda in the area of innovation for development. An important role in this challenging area in the future will be played by international collaboration and networks of policy-makers, private sector, NGOs and research communities. One example of such networking is the Network for Asian Science, Technology & Innovation Policy (NASTIP), established in November 2010 during the conference on “World Conclave of Scientists on Regional Co-Operation in S&T: Opportunities and Challenges in the Context of Globalization” in New Delhi, India in 26-29 November 2010 (Khan and Loikkanen 2010).
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Appendix 1: Global investment in R&D in 2007 and scientific specialization of the Triad, BRIC countries and Africa in 2008

Figure 1. Global investment in R&D in absolute and relative terms for selected countries and regions, 2007 (Source: UNESCO Science Report 2010).
Figure 2: Scientific specialization of the Triad, BRIC countries and Africa, 2008


Chart 1: Amount to Net Official Development Assistance (NOA) in 2008 (Source: OECD, 14 April 2010)
Chart 2: Net Official Development Assistance (NOA) as a percentage of Gross National Income (GNI) in 2009 (Source: OECD, 14 April 2010)


Chart 1: Components of Net Official Development Assistance (NOA) 2000 - 2008 (Source: OECD, 14 April 2010)
Chart 3: Components of DAC donors’ net ODA in 2008 and 2009 (Source: OECD, 14 April 2010)

Prof. Zahid H. Khan making his presentation
ICT and the Changing Face of Higher Education

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Abstract

Starting with a brief description about the use of computers in education, the paper discusses the far-reaching applications of ICTs in reshaping the face of the higher education in the new Millennium. It also sheds light on e-resources, open educational resources and learning management systems. The various challenges of higher education are mentioned briefly and it has been shown as to how ICTs can be helpful in resolving them. The emergence of Web 2.0 – the social web and its influence on the present day students is well understandable. We have briefly discussed the use of this new technology in teaching, learning and research. The salient features of India’s initiatives through the National Mission of Education through ICT are highlighted where the main focus is content development in all Indian regional languages and networking of all universities and colleges with the aim to provide free online content to every Indian citizen and thus bridging the digital divide. It is followed by a case study of ICT in Jamia Millia Islamia, which particularly highlights the implementation of e-management and e-governance in the university, which is certainly helpful in bringing greater efficiency and transparency in the system. The paper concludes with the upcoming technologies which will certainly have a direct bearing on teaching and learning and help in bridging the digital divide.

1. Introduction

Computers have been used in education since late 1960s when they were primarily deployed for computational purposes, either for research work or for preparation of data concerning students and their examination results. Initially computers were quite large and voluminous and hence users did not handle them directly. However, the development of fast microprocessors and their mass production paved the way for less expensive microcomputers in the mid-1970s. In the 1980s, microcomputers were widely used in schools. The advent of ‘personal computers’ with better computing power was the next important development. PCs entered the market in a big way in the 1980s once they became more affordable. This was accompanied by the development of digital printers and new storage devices with their ever increasing storage capacity and the miniaturization of their size.

It was, however, the proliferation of World Wide Web and the Internet that revolutionized the use of Information Communication Technologies (ICTs) in the field of education. From the mid-1990s the use of ICTs in education received further impetus through e-mail, World Wide Web, Internet, networking, software improvement, and professional development of teachers (Paas, 2009). In the new Millennium a variety of new technologies, such as the Web 2.0 – the social web, e-learning and m-learning technologies, e-book readers, cloud computing, etc. were developed. This was accompanied by the development of digital resources for teaching and learning, open educational resources (OERs), new software tools, online courses, e-labs, and online labs. These technologies have thus brought a new revolution in universities, which are now emerging in the form of digital universities.
Currently, there are various challenges to higher education, viz., quality assurance in education, digital divide, access and equity, quality faculty with IT skills, Internationalization of higher education, financing of education, constraint of time and place, learner-centric education, management of exponentially growing information and knowledge, e-management of higher education and e-governance of educational institutions. The ICT have demonstrated their capability to address the above issues effectively. Thus the future of universities will now depend on their capability to adapt these new technologies and apply them in teaching and learning and effective management and governance of higher education.

2. ICT in Education

According to Anderson (2010), the term “Information Communication Technologies” (ICTs) covers the following various types of electronic tools by means of which one may gather, record and store information, and also exchange and distribute information to others. Such tools are: computers, desktops, notebooks, tablets, PDAs, floppy disk drives, hard disk drives, CDs, DVDs, flash drives, memory cards, printers, scanners, camera phones, data projectors, digital cameras, camcorders, radio, television, networks, Internet, WiFi, modems, routers, mobile phones, instant messaging, voice over Internet protocol, e-mail, videoconferencing, interactive white boards, MP3/ MP4 players, e-book readers, GPS (global positioning system), etc. This is in accordance with the following description ICTs given by UNESCO:

“….. the tools and processes to access, organize, manipulate, produce, present and exchange information by electronic and other automated means. These include hardware, software and telecommunications in the form of personal computers, scanners, digital cameras, phones, faxes, modems, CD and DVD players and recorders, digitized video, radio and TV programmes, database programmes and multimedia programmes” (UNESCO Bangkok, 2003, p. 75, in Paas, 2008, p.4).

The new ICTs, particularly the Internet and its applications, have a great impact on the process of teaching and learning. Earlier, the conventional training imparted by universities was limited in space and time. ICTs have removed this barrier and a learner has now the possibility to learn anywhere anytime. The age is also no bar and now one can learn for the entire life (lifelong learning). The enormous amount of knowledge that was created by universities was earlier limited to a handful of students. The scenario has now changed; the knowledge is now no more confined in a box, but it is open and anyone may be benefited from its vast reservoir.

It is now realized that education cannot be imparted to a vast population through conventional universities. The information communication technologies offer the promise to reaching the greatest possible target population at nominal cost through “virtual” universities, which have now become a reality. Also, the cost of education in universities is growing year after year, whereas their funding is decreasing. There is a pressure from the society that the university education should be more cost effective. Moreover, an important factor that universities have to seriously look into is competitiveness. The students have to select universities of their choice and they would naturally prefer such universities that offer better services and courses and produce students that have better options for employment. The universities will have to compete in the education market. Another pressure on universities is that they should produce students that are computer-literate. This, in turn, demands that the university and its teachers should be equally familiar and equipped with new technologies.

Thus universities have to take appropriate decisions to adapt ICTs in all of its sectors so as to achieve better quality in education and bring out students that fulfil the requirement of the professional
market. In other words, it means that the future of universities now depends on their capability to adapt to the new information society and its requirements.

2.1. ICT in Teaching and Learning

ICTs are widely being used in universities in the form of text editing, e-mail, Internet, file transfer, world wide web, discussion groups, chat rooms, video conferencing. Scientific literature, books and journals are being accessed through world wide web (Langlois, 1998). In particular, for science and engineering students, simulation experiments and virtual labs are now accessible where they can perform experiments from remote locations. Virtual classes provide yet another great advantage to students.

Development of course content is an important area in which universities have to put in their efforts. Universities can create pools, internally or with other universities, to offer more training facilities, and develop educational packages that would also be at the disposal of students in remote areas.

The use of ICTs in education is bound to bring out a significant change in the style of learning in which students will have more control of their education. There will be more emphasis on learning rather than teaching, the process being more learner-centric rather than teacher-centric. Students can receive teaching anywhere anytime, throughout their life (life-long learning). This will be accompanied by the change in the role of teachers, whose new role will be to act more as facilitators and transmitters of knowledge.

ICT offers several advantages, some of which are: bringing motivation among teachers and learners, making a positive difference to learning, supporting personalized learning, facilitating greater choice of subjects, producing better test results, promoting learner autonomy, lessening the burden on teachers and learners, allowing teachers and tutors to teach more effectively, better record keeping, and helping in efficient tracking of learner’s progress.

2.2. ICT in Research

Researchers are one of the major beneficiaries of ICTs. The use of e-mail services, file transfer (ftp), searching of literature, submitting research papers for publication, electronic publishing has made their life very easy. Digital libraries, online publications and possibility of sharing of remote computer resources are other important facilities that ICTs offer. The following Fig. 1 shows a glimpse of the homepage of the UNESCO Bangkok e-Library:
3. E-Learning

According to Kante (2003), the e-learning involves the use of some form of electronic media to enhance the learning process. On the other hand, Resta and Patru (2010) are of the view that e-learning is learning by communicating using the Internet and interacting with content accessed on the Internet, all within the context of sound pedagogy. The above authors have given four basic categories of e-learning, viz., E-resources, Online courses, Blended learning, and Communities of practice. Based on this, Anderson (2010) has given a new definition of e-learning as using the Internet for communicating and locating content, within the context of sound pedagogy, to:

- access e-resources for classroom instruction,
- participate in online courses,
- provide blended learning by combining online content with other teaching methods,
- offer support for communities for practice to share ideas and experiences.

In comparison to conventional learning, the e-learning offers several advantages, viz., learning can be done anywhere at anytime; it is learner-centric and can be fitted within one’s busy schedule; it can be more focused on the learner and less on the instructor.

4. E-Resources, OERs and LMS

4.1. E-Resources

Enormous e-resources and online resources are now available, many of which are available in the open source. These include e-libraries, online books, journals, dictionaries and thesaurus. Some of the useful references for such resources are given below:

Project Gutenberg (www.gutenberg.org/wiki/Main_Page)

(It offers to download over 33,000 free ebooks to read on PC, iPad, Kindle, Sony Reader, iPhone, Android or other portable device).


(An online store of books).

Google Books (www.books.google.com)

(An online store of books).

Dictionary.com (www.dictionary.reference.com)

(An online dictionary).

4.2. Open Educational Resources (OERs)

The most important example of open educational resources is the Open Course Ware (OCW) pioneered by the Massachusetts Institute of Technology (MIT) that provides free access to 2000 courses for students, teachers and self-learners. A list of several OCW initiatives is given below (D’Antoni, 2008):
4.3. Learning Management Systems (LMS)

Several Learning Management Systems are available that are responsible for managing and delivering digital learning contents. Some popular LMS are:

- A Tutor (http://www.atutor.ca/)
- Claroline E-Learning System (http://www.claroline.net.org/)
- Moodle Course Management System (http://moodle.org/)

5. Web 2.0 in Higher Education

The concept of Web 2.0 began with a conference brainstorming session in 2003 between O’Reilly (2005) and MediaLive International. According to Wikipedia, Web 2.0 is associated with web applications that facilitate participatory information sharing, interoperability, user-centered design and collaboration on the World Wide Web. A Web 2.0 site allows users to interact and collaborate with each other in a social media dialogue as creators of user-generated content in a virtual community, in contrast to websites where users are limited to the passive viewing of content that was created for them. Examples of Web 2.0 are: blogs, podcasts, wikis, video sharing sites, social networking sites, RSS feeds etc.
The Web 2.0 or Social Web technologies have become very popular amongst the student community. It has been found that the process of engaging with Web 2.0 technologies develops a skill that is significant for developing learning skills and also the employability skills – communication, collaboration, creativity, leadership and technology proficiency (JISC Report, 2009). The web 2.0 offers several advantages for students. For instance, “blogging” develops writing skills in students and they can share their views with other colleagues. On the other hand, “podcasting” allows students to access lessons in their own time, enables to create dynamic presentations without the complexity of digital video, enriches information through sharing of audios and comments by other listeners, and improves presentation skills in students.

“RSS (Really Simple Syndication) Feeds” makes it possible for people to keep up with their favourite web sites in an automated manner that can be piped into special programs or filtered displays. Thus they are extremely useful for those who want information stored at a site from where it may be easily retrieved. “wikis” are also gaining popularity in education. Students may use a wiki to collaborate on a group report, compile data or share the results of their research. Social networking sites like “Facebook” and “Twitter” have gained enormous popularity in recent years and they are now frequently used for sharing academic information.

In Fig. 3 a video clipping from the YouTube is reproduced, demonstrating the effective use of such sites for uploading videos or lectures.
Apart from the above, there are wiki-based sites like “Curriki” (http://www.curriki.org), which stores e-content that can be revised and updated by the users. Another important curriki-based site is “Livemocha” (http://www.livemocha.com) – a language learning site, that can be updated or revised by the learners.

6. Indian Initiatives on ICT in Education

In 2009, the Ministry of Human Resource Development, Government of India has taken an initiative under the “National Mission on Education through ICT” (NMEICT) with a grant of Rs. 46,000 million. The most important features of this initiative are:

- E-Content Development,
- Networking of 600 Indian universities and 22,000 colleges,
- NPTEL Project,
- Development of low cost computing devices.

A detailed information about the NMEICT initiative is available at: http://www.sakshat.ac.in/.

The NPTEL programme is being carried out by seven IITs and IISc Bangalore as a collaborative project. Its main objective is to enhance the quality of engineering education in the country by developing curriculum based video and web courses. In the first phase of the project, supplementary content for 129 web courses in engineering/science and humanities have been developed. Each course contains materials that can be covered in depth in 40 or more lecture hours. In addition, 110 courses have been developed in video format, with each course comprising of approximately 40 or more one-hour lectures. In the next phase other premier institutions are also likely to participate in content creation. The courses may be accessed through: http://nptel.iitm.ac.in/.

7. ICT @ JMI - A Case Study

In this section, a case study of Jamia Millia Islamia (JMI) is presented which demonstrates as to how we have created an IT infrastructure in the university, which is the basic requirement for its transformation from a conventional university to a modern 21st century university.
The University has a campus-wide LAN with 4,500 Internet nodes, connecting all of its buildings through optical fiber. Through the National Knowledge Network, the university has been provided a 1-Gbps Internet bandwidth. This is in addition to 42-Mbps bandwidth available through the Software Technology Park, Noida and ERNET, India. The website of the university has more than 15,000 web pages. For automation of the functioning of university’s offices, the university has its own MIS (Management Information System) which has all the important modules shown in Fig. 4.

![Fig. 4. Various modules of the Jamia Management Information System](image)

A report on admissions generated through the MIS is displayed in Fig. 5.

**Jamia e-Governance Website**

The university’s e-Governance website (Intranet Link: http://egov.jmi) provides useful information to employees and students of JMI. These include:
Links to other online Internet and Intranet services of the university,

Complaint Manager,

Software Download,

E-Learning Resources.

**KnowledgeGate** (http://knowledgegate.jmi)

From the KnowledgeGate server, lectures, teaching material, reference manuals etc. may be shared in digital form.

**Moodle – The LMS** (http://moodle.jmi)

This site provides facilities for creating online courses. It may also used to create Wikis, Forums, Chat rooms and sharing electronic digital contents.

**Capacity Building of Staff**

Regular training of faculty and staff is essential for successful implementation of ICTs in various sectors of the university. Training for the staff on computer fundamentals and MIS are held whenever there is such requirement. The university has signed an MOU with Microsoft (India) under...
which the faculty members are given training to enhancing their IT skills. A training session conducted by Microsoft Corporation for the faculty members of the university is depicted in Fig. 6.

![A training session conducted by Microsoft Corporation (India)](image)

Fig. 6. A training session conducted by Microsoft Corporation (India)

8. Concluding Remarks and Future Trends

This paper gives an overview of application of ICTs in higher education, demonstrating that the future of universities lies in the effective use of such technologies. The e-learning technologies are particularly found to be very useful for learners as there is no restriction of time and place – one can learn anywhere anytime. The ICTs can further bridge the digital divide and education of the masses will be a reality once Internet connectivity is made accessible to rural masses. The future lies in the use of mobile technology in education: m-learning which is not very far. Development of e-contents in regional languages is a real constraint, but lots of researches are going on in this direction. The development of “Kindle” by Amazon is one of the very useful devices of this decade and now a number of companies are manufacturing “e-Readers”, which have become less expensive and affordable. It is already bringing a new revolution, making “digital pocket libraries” a reality.

References


Science & Technology Policy Studies
Dr. Raine Hermans
Smart specialization based on trade theories: case of Finnish regional innovation systems

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Abstract

This present study is an attempt to shed light on the current development phase of Finnish innovation system facing a new paradigm based on cross-cutting competencies and foresight themes on market development. The Finnish innovation system is seen as a mosaic of regional innovation systems. The regional innovation systems are analysed through a developed framework including elements of theories of innovation systems and theories of international trade as well as two recent national strategy papers. One of the main concepts of the study is related variety in regional innovation platforms. The present study also aims at creating a pragmatic framework for describing related variety at regional level by combining two theoretical frameworks seldom seen in the very same research article. The empirical data was gathered in a series of workshops in all the Finnish regions during the year 2008. The result maps Finnish thematic regional innovation platforms fueled by smart specialization.

Keywords: smart specialization, innovation platforms, regional innovation systems, international trade theories

1 Introduction

Innovation policy in Finland has been very much equivalent to science and technology policies, which has proved fairly successful, as indicated by various international surveys and indexes. The distinct strength of Finland is in managing STI (science-technology-innovation) activities and pursuing high-class knowledge production in selected fields. The ongoing change process of the university structure is carried out in order to keep Finland at the top of knowledge production. The same direction is supported through the establishment of Strategic Centers for Science, Technology and Innovation (henceworth SHOKs – the Finnish acronym). The aim is to concentrate on niche expertise fields in Finland to fight for the place in the sun in global networks. It has, however, been shown (Harmaakorpi & Melkas, 2008; Mustikkamäki & Sotarauta, 2008), that innovations are often practice-based and they are generated in innovation environments that are of many different shapes. It is possible to enhance this kind of innovation activity by developing systems and methods in regional innovation systems. Still, the development measures in practice-based innovation activities (DUI – doing-using-interacting) have been much less specified than those of STI activities (Berg-Jensen et al. 2007).

The discourse that led to this publication includes the question how regional potential can be exploited especially when enhancing practice-based innovation activities. The potential is here seen supportive of science and technology based innovation activities. It is evident that the better organized the regional systems and methods are, the more certain it is that research results are rooted as innovation activities in Finland. Developing regions (or territories) are not a wasteful zero-sum game, since (Camagni, 2002):

- competitiveness reached through territorial quality and public service efficiency brings benefits to all local economic activities, both originating from inside or from outside
• competitiveness reached through spatial specialisation means widening roles for complementary specialisations, developed in complementary territorial contexts

• competitiveness reached creating local synergies among actors, or integrating and embedding external firms into the local relational web, exploits technological and organisational spill-overs and generates increasing returns that are at the very foundation of economic development, in its generative sense.

International free trade agreements and economic integration are based on the exploitation of the comparative advantage of different regions. According to this, free trade is thought to develop and benefit all the participating regions and states and not just those that have greatest resources, with significant critical mass and thus an absolute advantage to produce commodities of a certain field of application (Leamer, 1984). If only the big regions with advantage-based superior numbers in resources could have a wide enough base for expertise, the activities in many applied fields would have concentrated on totally international centres for instance in the USA. Still, according to the principle of comparative advantage, also small regions with a fairly high percentage of expertise and other resources to produce individual applications or activities seem to prosper when focusing on developing application fields and activities according to the comparative advantage (Krugman and Venables, 1995, 1006). The resources need not be related to physical or intellectual characteristics in certain fields of application; they may be for instance social or institutional structures which become visible in high-grade practices of regional innovation system.

In smaller regions, the competences and themes become visible in thorough search. The regional actors may emphasise expertise or structures that are not seen as “expertise” at the national level. On the other hand, in bigger regions the competences and the themes consist of entities that are more general in nature. This study may be considered equal to realizing the principle of comparative advantage in the regions. Smaller regions may, in their innovative activities, concentrate on developing selected fields of application or activities (for instance management of DUI processes) when the principle of comparative advantage is realized, and concurrently create an adequate critical mass to develop the activities. If the resources are scattered in the small regions, it is not possible to create a sustainable foundation from the viewpoint of comparative advantage or critical mass of competences. Traditionally, the problem has been in the way of thinking. Spatial strategic specialisation is seen to be related to the strong industries in the region, which notion, in turn, has led to a competition over the ‘favours’ of the regional funders. Then it has been very difficult to find a solution for regional expertise, satisfactory to all actors. Instead, effort should be put to finding mechanisms that support the development of fields of application and practices aiming at new growth in the future (Redding 1999).

This strategic round-up strives to cross over industrial borders and to exploit information gained from international foresight research on market evolvement. This information has been compiled as strategic themes, presented in Tekes23 (The Finnish Funding Agency for Technology and Innovation) strategy (Tekes 2008). The use of the strategic themes makes it possible to guide companies to exploit the future growing markets in focus areas. As the growing markets overlap in the applications of many industries, the regional industries are not competing with each other in thematic planning. On the contrary, the companies are challenged to make a strategic decision whether they

23 Tekes is the most important publicly funded organisation for financing research, development and innovation in Finland. Every year, Tekes finances some 1,500 business research and development projects, and almost 600 public research projects at universities, research institutes and polytechnics.
want to develop products and service concepts for the future, and participate in business activities that are directed to the growing markets.

The objective of this strategic round-up is to combine the regional focus areas and their competences into the strategic themes led from the Tekes (2008) foresight report, which will be described in more detail further in the text. Also, the test markets related to the focus areas and themes, as well as the characteristics of the regional innovation system are described. The test markets are especially important in demand-driven innovation activities to receive high-quality feedback on the development work (Hermans & Kulvik 2006). The regional innovation system in its turn enhances the activation of companies and research institutes into innovative activities and interactive collaboration to generate innovation (Harmaakorpi & Melkas 2008).

Commensurable description of regional strengths is a part of finding natural links between interregional collaboration. For instance, if one region lacks competences related to one certain theme, the actors may benefit from the competences already existing in some other region, and not build their own regional education or research system from the start. Networked methods may help in gaining advantages of scale also in a small country. Interregional collaboration is prerequisite to responding as a small country to open international competition and to proactively strengthen the regional vitality.

During the study, developing new regional innovation strategies has not been our target; instead, we wish to give a comprehensive description of the regional innovation systems and environments. This work is seen to be a base for the future development of the polyphonic innovation system consisting of the regions in Finland. The regional data was mainly collected in a series of regional workshops where the key actors having an impact on regional strategies were invited. The objective of the process was to give a comprehensive picture on the innovation systems and thematic innovation platforms of the Finnish regions. The research setting and process is depicted in Figure 1.
2 Analytical background of the strategic initiatives by theories of international trade

The intensifying economic integration necessitates the evaluation of potential niches which the regional actors could profitably focus on when developing their products and services. When seeking to identify these niches, the regional competence-base in the industry and academia must be comparatively large to generate the critical mass of competencies necessary for spawning successful products and services for the international markets.

Key success factors for the regional economy include the ability to (1) take advantage of domestic strengths while acknowledging limitations of available resources, and (2) to maintain a global view of the markets. The dynamic strategy framework is based on concepts outlined in the following sections (Hermans, Kulvik and Löffler 2009).
2.1 Comparative advantage

Ricardo’s concept of comparative advantage serves as the foundation of trade analysis and as a basis for further modeling tradition. For instance, the Heckscher-Ohlin-Samuelson approach links the regional factor proportions and their productivity to the comparative advantage of regions (Flam and Flanders 1991; Samuelson 1948). There have been an extensive number of theoretical contributions and empirical investigations both to the Ricardian and the Heckscher-Ohlin-Samuelson modeling tradition up to the present day.

According to the trade literature, all trading regions will gain if each region is specialized in production at a lower opportunity cost than other regions. Particularly when trade barriers get lower, according to the Heckscher-Ohlin model, a region benefits if it increases the production of goods produced by the relatively abundant factors.

A small open economy (e.g. small countries or states within a large country) has limited and scarce resources. Therefore, it is not economically reasonable to produce all the products for domestic markets itself. According to comparative advantage it is necessary that regions specialize in some specific industries utilizing a specific combination of relatively abundant factors of production.

**Proposition 1:** There will be economic overall gains within a free trade area if an industry utilizes a resource and capability combinations that is regionally comparatively abundant.

2.2 Market structure and spatial agglomeration

Krugman and Venables have emphasized a new geography-based approach to economic analysis (Krugman 1991; Krugman and Venables 1995; Venables 1996). Specifically, they analyzed how market structure is related to the location of economic activities. Their modeling of market structure was based on Chamberlin-type monopolistic competition as presented by Dixit and Stiglitz (1977). The primary goal of the original analysis is to show that higher sunk costs in industrial production (e.g., higher M&A or R&D costs) are associated with more differentiated products for consumers. At one extreme, there would be only a few producers with greatly differentiated products. At the other end there would be an infinite number of low sunk-cost producers, in a scenario in which the consumer prefers a large variety of less differentiated products.

Krugman extends the model of monopolistic competition to the context of spatial structures (Krugman 1991). In the geographic centre-periphery model there are three market features affecting spatial structures:

1. Increasing returns to scale in a manufacturing sector are related to higher sunk costs associated with production processes. This, in turn, promotes the strengthening of the geographic center-periphery structure.
2. The higher the sector’s usage of available production factors, the more a centre-periphery structure gains strength. This effect implies that firms benefit from a local concentration of production factors, such as individuals seeking employment, incur lower costs due to the geographic concentration of companies.
3. Lower trade barriers or lower trade costs imply a tendency towards the spatial agglomeration of a sector showing increasing returns to scale in its production process. The firms can also subcontract with each other locally, with relatively low coordination (e.g. transport of inputs) costs (Krugman and Venables 1995; Venables 1996).
Geographic economics stresses the importance of market structure (e.g., how the M&A and R&D cost structure affects the size and number of companies in the industry), which can be related to the efficient allocation of resources and access to local test markets.

Proposition 2: Region attracts companies and capabilities as a basis for value adding activities if there is a critical mass of capable resources and local [test] markets available.

2.3 The Infant Industry argument

In the 19th century Hamilton and List argued for the public support of infant industries in order to achieve an advantage over other countries (Krueger and Tuncer 1982; Shafaeddin 2000). The infant industry argument (IIA) is based on the temporary need for protection (or support) of an infant industry if the industry is unable to grow in the international context of free trade and foreign rivals. The initial excessive costs of such industry support are assumed to be compensated for by the surplus profits and economic growth of the later stages, returns that could not have been captured without initial governmental support. However, IIA has been miscast as an argument for exceedingly long-term protection, which was not its framers’ original intent.

There are some basic arguments that provide a rationale for directing supporting activities at infant industries, such as cumulative learning within the infant industry through the creation of positive externalities. The potential externalities over time include, for example, the availability of technically competent labor, technological spillovers, and diminishing transport costs due to the creation of a local cluster. If these externalities could be created only through governmental promotion, and if the long-term GDP effects exceeded the initial short-term costs of the promotion, it would be reasonable to provide temporary support for an infant industry. Thus, the infant industry argument diverges from the static trade restriction schemes which protect domestic industry through permanent import tariffs or quotas, or by other long-term means. In a modern free trade framework, however, IIA can be extended to have similar reasoning as modern subsidy programs of governments. For instance, the innovation activity of a region can be vastly subsidized in order to support the ability of the region to apply new (or the same as its rivals) technologies and concepts.

A small open economy cannot afford to produce all products itself, but it could gain from the creation of a critical mass in some niche markets. The infant industry argument stresses the importance of subsidizing regions that are incapable of becoming globally competitive on their own. The temporary aspect of the subsidies is, however crucial, irrespective of what forms they take (e.g. tax privilege, corporate subsidy, other forms of government funding).

Proposition 3: Short-term government support to strengthen emerging resources and capabilities within an infant industry (or developing region) aims to promote positive externalities and an economic upside in the long term.

2.4 Cluster dynamics

Even though challenged in the previous chapter, Porterian cluster model is still a worthy basis for analyzing regional competitive factors. Porter (1990, 1998) concludes the discussion on spatial competitiveness with a discourse on the ability of industries to create incremental and radical innovations. In Porter’s diamond model, innovation intensity depends on the interaction among four attributes: factor conditions, demand conditions, related and supporting industries, and market structure. Skilled labor and a well-developed infrastructure are critical factors for production and
innovation; if there are demanding sophisticated customers in the domestic marketplace, companies are forced to be innovative. An internationally competitive supporting industry is crucial to the availability of cost-effective inputs. Competitive domestic markets with innovative rivals intensify the innovation processes, and reinforce the development of first-mover strategies.

Proposition 4: The interaction of highly specialized factors of production, demanding domestic customers, internationally competitive supporting industries and intensive domestic competition creates an innovative and competitive industrial cluster.

2.5 Synthesizing the theories into a dynamic framework

Due to global competition and rapid technical development, an industry, based in a small open region, needs to find pathways to innovate through collaboration with the academia (located even outside the region) and other industries in a way that complements its capabilities and experience. The industry and other related industries benefit when knowledge (in technology, distribution channels and service concepts) could be shared and utilized. The complementary competences enabling the knowledge spillovers are called related variety. The utilization of related variety can impact significant externalities in the region and thus contribute to the industry’s and region’s growth.

The four central concepts presented above have traditionally been viewed as mutually exclusive. However, we believe there is significant value in fusing even seemingly contradictory frameworks or sectors into a more comprehensive framework. As the industry extends well into global markets, it seems logical to focus on the value of combining central frameworks derived from the literature of international trade. The combination of the implications can be stated as follows:

Proposition 5: Create and utilize a related variety of or in i) cross-cutting capabilities and infrastructure, ii) foresight-based demand driven business strategies, iii) internationally competitive supporting industries and iv) regional test markets providing feedback. Strengthen temporarily those parts of the infant technology cluster which are critical for long-term growth and success.
Figure 2. The combination of our distinctive research paths in the strategic context of international trade analysis

The developed framework places our findings in the context of a small, open economy’s innovation system as it faces global markets in two regards. First, technologically significant and economically valuable intellectual property rights provide a base for the construction of a business strategy to exploit the sophisticated domestic markets in forging a pathway to the global markets. Second, regional specialization of commercialization activities can provide a critical mass of competencies that serves as a base for specific industrial clusters. If the infant industry could provide complementary competencies and earning prospects for more mature industries in the future, these could justify financing and facilitating the development of the infant industry. The greatest challenge was related to a difficulty to form forecast-based viable business strategies and themes which can be used to communicate the strategy. Below we aim to confront this challenge.

3 Research setting and methodology

This initiative exploits both the focus areas based on the international foresight work of Tekes and the most important trends presented in literature analysis on international trade.
According to the principle of comparative advantage, international trade partners benefit if economies specialize in areas utilizing relatively abundant production related resources (Learner 1984; Redding 1999). According to monopolistic competition and new economic geography, geographical peripheries (like Finland) can attract companies on the basis of value-added functions, if there is critical mass of location specific but globally scarce resources available in the region (Krugman 1991; Forslid & Wooton 2003). The traditional argument of public governance role in developing domestic industries is known as infant industry argument. According to this theory public sector can strengthen emerging critical resources within an infant industry and thus aim to promote positive externalities and an economic upside in the long term (Krueger and Tuncer 1984). According to literature on cluster dynamics, the interaction of highly specialised resources, sophisticated domestic customers, internationally competitive supporting industries and intense domestic competition create an innovative, competitive industrial cluster (Porter 1990, 1998).

To view the regional strategies, a comprehensive framework has been fused to evaluate all regional strategies. The simplified framework allows a commensurability of the regional strategies which makes it readable. The weakness lies with the obscuring of the regional characteristics. An effort has been made to avoid this by allowing a diverse inspection of the different regions, maintaining the upper level titles. This also brings a certain kind of ruggedness to the publication.

The framework is studied from three different points of view. The crucial point of view consists of the framework implications of Tekes report “People-Economy-Environment – Choices for building the future”, which paved the way for Tekes’s strategy process. In addition, findings from the theories on international trade and innovation systems were added to the framework. Based on a literature review, the following components were included in the framework developed and to be later defined during regional workshops (Figure 3):

a) cross-cutting competences and structures
b) thematic regional innovation platforms (based on drivers for change)
c) the internationally competitive industries of a region
d) access to demanding test markets
e) ways of action of innovation systems.

Empirical data was collected in a series of 18 regional workshops, which were held during spring and autumn 2008. Each regional workshop had 15-20 participants representing organizations that had contributed significantly to the development and carrying out of regional strategies. They included regional authorities, representatives from universities, polytechnics and also private companies. Altogether almost 300 regional decision-makers participated in the workshops. During each workshop a regional strategy profile (see Appendix 1.) was created using a developed framework and by answering the following questions.

a) Cross-cutting competences and structures

Which kind of relatively abundant innovation generating cross-cutting competencies create the basis for regional competitive advantage? What are the concrete “spearhead competencies” in the region? What special (organizational) structures providing services for industries exist in the region?
b) Region’s Internationally competitive industries

What are those industries, where cross-cutting competencies can generate the greatest benefits? Which industries of the current industrial structure are in a dynamic phase having possibilities to succeed in international competition in the future?

c) Thematic regional innovation platforms (based on related variety)

What are the drivers for change creating potential for innovations in companies located in a region? How can these drivers fuel regional innovation platforms? Where can synergies between competencies and industries be found? What kind of regional innovation platforms can be outlined in the region?

d) Access to demanding test and lead markets

What kind of test markets can be found for products/services developed by using cross-cutting competencies in order to get valuable feedback for internalization and going global? Where will the main markets be?

e) Practices of a regional innovation system

How are innovation activities promoted and facilitated in a region? What kind of renewal processes can be identified in regional innovation system? What kind of methods and approaches are used to anticipate user needs? How is public and private sector partnership and cooperation promoted (including knowledge transfer and cooperation between research organizations and other organizations)? How is the creation of global value networks facilitated? How are possibilities provided by effective use of ICT utilized in innovation system?

After each regional session researchers quickly produced a first draft of a regional report, which was then reviewed and commented by workshop participants during two feedback rounds, before writing the final version.
4 Analysis of regional innovation systems

4.1 Regional thematic innovation platforms

Regional thematic innovation platforms can be understood as offering important two dimensional benefits: vertical and horizontal dimensions. One key element in creating regional innovation platforms is the identification of those new combinations of regional cross-cutting competencies and internationally competitive industries that can offer potential for future innovation generation. When referring to vertical dimension, the innovation platforms are serving regional strategies and goal setting by helping regional actors to allocate scarce resources in a way which purposefully supports long term competitiveness renewal of the region. On the other hand, when referring to horizontal benefits, the regional innovation platform approach helps the policy makers at national level to identify the regional focus areas, similarities and differences thus helping to find synergies between regions.

Both cases of the dimensions of regional innovation platform will be elaborated in this article by concrete examples. The region of North Karelia acts as an example of vertical dimension of regional innovation platform and a theme of well-being and health related innovation acts as a demonstration of horizontal approach of innovation platforms.

In Table 3. (see also Appendix 2.) the results, regional thematic innovation platforms based on a concept of regional related variety, are presented in a nutshell covering all 16\(^{24}\) regions, which were participating in this research process. Constructing the thematic innovation platforms was found to be

\(^{24}\)The island of Ahvenanmaa was left out from this exercise due to its special character.
a difficult and troublesome task in most regions. Cross-cutting competencies and dominant clusters and industries were much easier to piece together. This is quite understandable, since this kind of related variety based development approach is relatively new, while in Finland the cluster-based development approach has been very dominant during the previous decade and a half. Thus, most of the regional strategy documents aiming at facilitating the regional development were written in “cluster language”.

Table 3. Thematic Regional Innovation Platforms based on Related Variety

<table>
<thead>
<tr>
<th>Region</th>
<th>Related variety innovation platforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Ostrobothnia</td>
<td>Clean energy and scarce resources solutions in food chain management and individual energy solutions; Well-being and health in sport and nourishment concepts; Intelligent systems and environments in material handling systems; Built environment based on timber construction; Customer-driven service business and event management concepts for creative businesses.</td>
</tr>
<tr>
<td>South Savo</td>
<td>Solutions for comfortable and Secure housing and recreational services; Ecological methods in agriculture and energy production; Intelligent and scarce resources systems and machines in industry; Measurement systems for the environment and Security technology</td>
</tr>
<tr>
<td>Kanta-Häme and Päijät-Häme</td>
<td>Intelligent systems in motor vehicles and material management; Services for built environment; Scarce resources solutions for waste recycling; Clean water and water resources management solutions; Energy efficient and scarce resources solutions; Services and appliances for promoting well-being and health; Built timber construction environment and scarce resources solutions for housing; Design-based service industry housing; Design-based service industry.</td>
</tr>
<tr>
<td>Kymenlaakso and South Karelia</td>
<td>Exploitation and processing of forest harvesting waste as clean energy; Scarce resources solutions for processing industry machinery; Intelligent well-being solutions in homes and in monitoring; Interactive social media.</td>
</tr>
<tr>
<td>Kainuu</td>
<td>Well-being and health in experiential industry; Intelligent systems and environments in motor vehicle data systems, intelligent solutions in old environments, processing industry systems and environments.</td>
</tr>
<tr>
<td>Keski-Suomi</td>
<td>Clean fuel systems of big energy producers; Clean solutions for regional and household heating systems; scarce resources solutions in industry; Scarce resources product solutions and solutions for management of life cycle costs; Intelligent integrated solutions for appliances.</td>
</tr>
<tr>
<td>Region</td>
<td>Related variety innovation platforms</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Lapland</td>
<td>Networked tourism and distant service concepts for well-being and health business; Customer-driven housing industry in arctic environment; and scarce resources solutions in health care and social services; Experiential or virtual systems and environments in tourism and Industrial services.</td>
</tr>
<tr>
<td>Pirkanmaa</td>
<td>Scarce resources solutions in production technology. Intelligent integrated systems and energy technology solutions; <em>Very human</em> interfaces and interactive mobiles in information society; Technological solutions in promoting well-being and health.</td>
</tr>
<tr>
<td>Ostrobothnia and Central Ostrobothnia</td>
<td>Clean energy by means of decentralized energy production; Scarce resources solutions for efficient electronics; Project activities and value-added services for industry; Built environment near waterfront; Intelligent scarce resources solutions in housebuilding; Well-being and health in geriatric care and in sport and nourishment concepts.</td>
</tr>
<tr>
<td>North Karelia</td>
<td>Scarce resources solutions related to timber harvesting and logistics; Solutions in clean energy use of wood; Intelligent nanotechnology and microtechnology solutions; Solutions of experiential industry, social media and education technology in interactive communications</td>
</tr>
<tr>
<td>North Ostrobothnia</td>
<td>Internet technologies and wireless solutions in interactive communications; Intelligent measurement systems and environments; Water systems and climate protection and cleaner energy solutions based on the use of wood; Front-end solutions for wellness and health technology as well as medicines development and agrobiotechnology.</td>
</tr>
<tr>
<td>North Savo</td>
<td>Development of clean energy chains and environmental business (fuel technology and bioenergy); Commercialisation of science-based well-being technology and services; Digital mechanical engineering, welding automation and production and product management in networks; Measurement and censor technologies in renewing traditional industries.</td>
</tr>
<tr>
<td>Metropolitan area</td>
<td>Well-being and development of a Healthy City; Construction of customer-driven, virtual services platforms and intelligent Identification systems; Development of service chains related to public procurement; ICT solutions for well-being.</td>
</tr>
<tr>
<td>Satakunta</td>
<td>Nuclear and bioenergy construction related solutions in technology, concept building and services; Implementation and management of international projects; Innovative solutions in the service structure of well-being and health business; Intelligent environments for security and civilian crisis management.</td>
</tr>
<tr>
<td>Uusimaa</td>
<td>Intelligent concepts, systems and environments for mechanical engineering; Intelligent systems and environments for electricity and electronics industry; Service business and service innovations in logistics industry; Clean energy fuel solutions; Comprehensive scarce resources solutions.</td>
</tr>
</tbody>
</table>
Region | Related variety innovation platforms
--- | ---
Varsinais-Suomi | Clean energy solutions in agriculture and food industry; Scarce resources solutions and

experiential concepts in marine industry and tourism; Technology exploitation in promoting well-being and health; Intelligent systems in food industry and environment; Innovative services.

4.2 Example of a region: North Karelia

The Region

North Karelia is located beside the eastern border of Finland and it has about 165,000 habitants. The province covers about 21,500 km² and the main center of the province is the town of Joensuu with its 72,000 habitants. The number of companies in the province is about 7,200 and the GDP is around 4.0 mrd euros.

Cross-cutting competencies and structures in the region

The main organizations responsible for knowledge and competence creation in the region are the University of Joensuu, Polytechnic of Northern Karelia, Laboratory of Mineral Technology of GTK (Geological Survey of Finland), Finnish Forest Research Institute (METLA) and European Forest Institute (EFI), which is one of the four research institutes in Finland having an international status. The core research and competence areas of the University of Joensuu are fotonics and spectral color research, material and bio-molecular research, forestry and environmental research.

Fotonics related competences are important in developing optical technology, which is a so-called enabling technology being applied widely in several industries. The most potential industrial applications can be found in information, imaging and communication devices, in lighting and display devices, production processes, quality control processes, in applications for health care and safety and security solutions and in reliability solutions. In North Karelia fotonics related capabilities are including micro- and nanofotonics, coherence and quantum optics, biofotonics, optical material research and spectral color research.

A second set of cross-cutting competences is related to material technology, which is playing a significant role in almost every industry. The main beneficiaries in the future will be metal, machine building, forest and energy industries. Those industries have reached a stable stage, but in the very near future they have to renew themselves radically. A precondition for this renewal is combining existing product portfolios with new material competencies and technologies. In Northern Karelia competences related to material technology include research on material chemistry, molecular modeling, research on unorganic and analytical chemistry, research related to catalysts, protein-cystallography and coordination chemistry.

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25 Due to a limited space, only one vertical and one horizontal example can be introduced here. All regions and themes were reported in similar manner in Harmaakorpi, Hermans and Uotila (2010).
Forestry related competences, in a wide sense, are a third set of cross-cutting competences in the region. That is understandable because wood is a most ample raw material in the region. Of special importance is the development of logging and harvesting technologies also including bioenergy related technologies, technologies developed for forest inventing and logistical solutions. Also, competences related to tool making, well-being services and information and communication technologies were brought up as cross-cutting competences in the region.

**Internationally competitive industries**

Internationally competitive industries in Northern Karelia were grouped into three categories. The first category included those industries that are exploiting local natural resources. By far the most important industries in this category are forest related industries, then come mining and quarrying. Also, concrete, glass and stone product production are included in this category. Of special interest and importance is the use of soapstone as raw material for stone products.

The second category of internationally competitive industries covers plastics and metal industries. Of special importance in this category are companies that are producing moving machines, tools of various kinds, devices for mining and metallurgical purposes, safety devices, composite products, devices for precise machine tooling and applications of injection moulding and component manufacturing for industrial purposes. The third category of internationally competitive industries covers so called experience industries referring to travel and tourism services, film industry and the production of hypermedia solutions.

**Theme based innovation platforms**

Regional theme-based innovation platforms emerged as combinations of cross-cutting capabilities and internationally competitive industries located in the region. In Northern Karelia three innovation platforms were identified. The first one is an already existing one while the two other ones can be understood as more emergent ones, being still in the construction or developmental phase. These innovation platforms are laid on a solid foundation created by already existing industries and cross-cutting competencies, but still aiming at mixing these elements in a novel way to create innovations for the future needs of markets.

The first innovation platform was named “Clean solutions in producing wood energy and logistical solutions with scarce resources in harvesting wood”. This platform was seen as the strategic spearhead of the region combining wide industry specific expertise from forest industry. The companies in the region can master the whole multitude of wood usage and they are already major operators in the global markets mastering not only several technologies but also customer relations. New possibilities can be found in promoting wood energy. The second innovation platform was named “Smart nano- and micro-technological solutions”. At the core of this platform are the capabilities related to the new material development and also nano- and micro-technological solutions. The core competences can be found around fotonics and composite related research and applied in toolmaking and safety technologies combined also with design know-how. The third innovation platform was named “Solutions for experience industry, social media and education technologies using interactive communication”. It was seen to have its innovation potential from combining the know-how of experience industry and a regional ICT-cluster.

**Access for demanding test markets**

The first and at the moment regionally the most important innovation platform is already having an access to global test markets, since the actors of this platform, for example the companies producing wood harvesting machines, are already global actors. Also, the second innovation platform
is well connected to global test markets. Companies operating in metal and plastics industries and producing new composite products and exploiting new material know-how or nano-technology related know-how are already connected to global test markets through their networks.

As for the third innovation platform, the demanding test markets must and can be found much nearer. Though the driving force behind the innovation potential of this platform is the global trend of ageing, the third innovation platform so far has no established connections to international test markets. This is due to the fact that the structure of the platform is much more fragmented than the other two. Entering international markets successfully necessitates networked local development activities, careful analysis of target niche markets and taking care that local and regional product portfolios are accordant with international standards.

Activities for developing regional innovation environment

In Northern Karelia, as well as in all regions in Finland, there is still much to be done, when developing regional innovation environment systematically. The most important notion is that actions supporting only the STI-mode of innovation (science, technology, innovation) are not alone sufficient but also the DUI-mode (doing, using, interacting) needs to be fostered. That tendency reflects well the current trend in the whole Finland, where new buzz-words in innovation policy debates are words like broad-based innovation policy, demand- and user driven innovation. However, concrete tools for promoting these goals are still very much on a drawing-board, in North Karelia and also elsewhere in Finland.

4.3 Example of a theme: Well-being and health

One of the eight main themes or drivers for innovation brought up in the report aiming to guide Tekes’s future activities is well-being and health. It provides an example related to the horizontal benefit of thematic innovation platforms. This theme aims at integrating economic growth with the well-being of people and the environment. Technologies and innovations are creating a basis for the achievements of society’s well-being and environmental goals (Tekes 2008). Special focus is on sustainable energy issues, the quality of health care services and regional vitality and regeneration. The term itself is multifaceted and can be interpreted in several ways. This on the other hand gives space for manoeuvres in implementing the theme in different regions. However, there are also regions in Finland, where this particular theme was not found to be an important driver for regional innovation platforms. Each region, where this theme was found to have importance, is aiming to combine this theme with its own regional strengths and cross-cutting competences. For example in Lapland, the area of which covers almost one third of the total area of Finland, but having only 185 000 inhabitants (about 3.5% of the total population of Finland) and thus being a very sparsely populated region, the focus of innovative activities is in generating health related distant service concepts. On the other hand, in Kainuu region, where one of the cross-cutting competences was related to sporting activities and tourism, the theme of well-being and health was strongly connected to experience related activities.

Again, in the region of Pohjois-Savo, this theme was strongly related to commercialization of science based well-being technologies and services. This kind of selection for supporting the STI-mode of innovation is very understandable, since the University of Kuopio, which is located in the region, is also one of the strongest research centers of medicine in Finland. This multitude is illustrated in Figure 4.
This kind of horizontal approach to thematic regional innovation platforms makes it possible to not only enhance the dialogue between different regions and find synergies between activities in different regions but also to deepen the dialogue between national and regional level actors. It also makes it possible for national level innovation policy actors to better coordinate the implementation of policy instruments at the regional level and makes it easier to allocate financial resources appropriately between different regions.
Figure 4. Focus of innovative activities in different regions relating to the theme of well-being and health
5 Conclusions

The present study assessed the mosaic of regional innovation systems in one country. In doing that it combined unorthodoxly two theoretical frameworks: the theories of international trade and the theories of regional innovation systems. Normally discussions between these theories have led to severe disagreements already in the start line of the intellectual exercise. However, in this case the theories gave a fruitful basis to an analytical framework including the main concepts of recent discussion in the mentioned theories: e.g. specialization, comparative advantage, agglomeration, new models of innovation and related variety innovation platforms.

The analysis consisted of 16 assessments of regional innovation systems in terms of cross-cutting competences and internationally competitive industries in regional workshops. These gave a picture of present resource configurations in each region. The analysis followed including strategic themes based on the drivers of change as defined by Tekes. This enabled to outline thematic regional innovation platforms fueled by a related variety, which was the main object of this study. The aim was to build new resource configurations having a comparative advantage in global competition. However, these resource configurations need to be promoted. Therefore, new practices and possible access to lead markets were defined in the final phase of the analysis.

The definition of cross-cutting competences and internationally competitive industries was relatively easily done during regional workshops. However, the thematic innovation platforms, demanding lead markets and new practices were very challenging or in some cases nearly impossible to define. From the innovation policy point of view conceptualizing these platforms at the regional level and promoting wide-ranging innovation activities is very important especially when considering national level resource allocation. It is not enough to develop regional competence base, the products and services developed must also reach global markets and regional actors must also be connected and act as part of global value networks.

In the practices of regional innovation systems outstanding single examples can be found. However, considering all things, there is still a lot of potential left for developing Finnish regional innovation systems. Only in few cases there were examples of methods and procedures to be found of how to renew regional innovation activities, how to facilitate and promote the creation of linkages between regional and global value networks, how to promote in a concrete way, the cooperation between public and private sector organizations, how to anticipate the development of user needs and especially, how to utilize ICT efficiently. This is perhaps due to the fact that formerly innovation policy in Finland at national level was mostly understood as science and technology policy and at regional level the content of innovation policy has very much been dominated by “cluster and industry driven-development thinking” aiming at “picking up winners”. Instead of picking up winners, our approach stressed the importance of the utilisation of strategic themes anticipating market trends. The themes challenge companies to make a strategic decision whether they want to focus on the business of their present industry or to develop products and service concepts for the future even in a new emerging industry and participate in business activities that are directed to the growing markets.

This present study reveals a necessity for a new kind of innovation policy framework aiming at creating and promoting smart specialization for regional innovation platforms. Otherwise, the potential existing in the platforms remains largely untouched.
References


Appendix 1: Regional profiles

Landscape Region seeks its strength from the natural resources and the unique nature industry and experiential industry. The most important drivers of the region are tourism, nature, and the close relationship between nature and environment is an essential element of the region to develop.

North Ostrobothnia Region is known for ICT related competences. ICT is exploited in the region in the growing ICT industry such as software, internet, and e-commerce. The region has the potential to transform into a business centre combining global, reproducible products and processes.

South Ostrobothnia is known for strong entrepreneurship and creative passion. Intelligent design, technology, healthy food products and sustainable exploration of natural resources.

Pirkanmaa Region is a diversified high-tech region combining management of intelligent engineers, health technology and ICT in open and creative cultural competences.

Satakunta Region is a pioneer region in research, power construction, and business skills in Finland. Having a world-class company network and developed active and conceptualized business processes for its member. There are also special skills in the region related to big projects and their supply chain management.

Vantaa-Suomen Region bases its competitiveness on diversified competences. Education and innovation. Special characteristics are international activities in maritime, electronics and electromonetics, machinery as well as medicine and diagnostics industry and logistics. Tourism and cultural services as well future research service concepts and valuing concepts are also potential growth areas.

Metropolitan Region is the most important and diversified centre of economic activities and research in Finland. It also the engine of Finnish economy and a world class innovative sector.

Kanta-Häme Region (Finland) has a wide range of industries which encourage the creation of new startups and innovation. The research and development facilities support innovation and business development. The regional innovation network connects universities, research institutions, and businesses. The regional innovation network is based on international level of innovation, development, and design competences.

West, Central and East Uusimaa Regions form a diversified and competitive region working in interaction with the Metropolitan Region. Growth areas are ICT, e-commerce, high-value added and e-commerce and internet services.
Appendix 2: Regional themes

North Ostrobothnia: Internet technologies and wireless solutions for interactive communications; intelligent measurement systems and environments; water systems and climate protection; and clean energy solutions based on the use of wood. Focus on solutions for wellness and health technology, as well as sustainable development and agrotechnology.

Ostrobothnia and Central Ostrobothnia: Clean energy by means of reconcentrated energy production; scarce resources solutions for efficient electronic; Project activities and value added services for industry; Built environment; near surfaces; Intelligent sensor resources solutions in householding; Wellness and health in geriatric care and in sport and recreation concepts.

South Ostrobothnia: Clean energy and scarce resources solutions in food chain management and industrial energy solutions; Wellness and health in sport and recreation concepts; Intelligent systems and environments in material handling systems; Built environment based on timber construction; Customer-driven service business and value management concepts and innovative businesses.

Tampere: Scarce resources solutions in production technology, intelligent integrated systems and energy technology solutions; Urban Human interface and interactive models in information society; Technological solutions in promoting wellbeing and health.

Salminen: Nuclear and bioenergy construction related solutions in technology, service building and services; Implementation and management of international projects; Innovative solutions for the service structure of wellbeing and health business; Intelligent environments for security and climate crisis.

Vantaa-Suomenlinna: Clean energy solutions in agriculture and food industry; Scarce resource solutions and experimental concepts in marine industry and tourism. Technology solutions in promoting wellbeing and health; Intelligent systems in wood industry and environment; Innovative services.

Helsinki: Wellbeing and development of a Healthy City; Construction of customer-driven, virtual services platforms; and Intelligent identification systems: Development of service chains related to public government, ICT solutions for wellbeing.

Lapland: Wellbeing and distant service concepts for wellbeing and health business; Customer-driven solutions for industrial, service and forestry solutions; Environment and scarce resource solutions in health care and social services; Experimental or virtual systems and environments in tourism and industrial services.

Hamina: Wellbeing and health in exponential industry; Intelligent systems and environments in motor vehicle data systems; Intelligent solutions in small environments; processing industry systems and environments.

Tampere: Development of clean energy chains and environmental business (fuel technology and bioenergy); Communication of science-based wellbeing technology and services; Digital mechanical engineering; welding automation and production; and product management in networks; Measurement and sensor technologies in removing traditional industries.

North Karelia: Scarce resource solutions related to timber harvesting and logging; Solution in clean energy use of wood; Intelligent nanotechnology and microtechnology solutions; Solutions of existing industries; Social media and education technology in interactive communications.

Kajaani: Solutions for comfortable and secure housing and recreational services; Development methods in agriculture and energy production; Intelligent and scarce resources systems and machines in industry; Measurement systems for the environment and geotechnological solutions.

Kymenlaakso and South Karelia: Exploitation and processing of forest harvesting waste as clean energy; Scarce resources solutions for processing industry machinery; Intelligent wellbeing solutions in homes and in monitoring; Interactive social media.

North-Savonia: Clean real systems and energy production; Clean solutions for regional and household heating systems; scarce resources solutions in industry; Scarce resource solutions in solutions for management of waste costs; Intelligent integrated solutions for appliances.

Kanta-Häme and Pirkanmaa: Intelligent systems for motor vehicles and material management; Services for health environment; Scarce resource solutions for waste recycling; Clean water and energy solutions; management systems; energy efficient and scarce resources solutions; solutions for promoting wellbeing and health; built timber construction environment and scarce resource solutions for housing; Design based service industry.
International Mobility as a Mechanism for Reproducing the Scientific Elite
(the Russian Case)²⁶

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Introduction

International scientists’ mobility is an important component of the scientific work. It facilitates to solve a lot of problems that scientists face: taking part in the global labor division, international projects, conferences, symposiums, joint publication of papers with foreign co-authors. The international mobility enhances the citation index, helps to receive international grants and awards. Now the international mobility becomes a significant tool of shaping the scientific elite. Our paper analyses the international mobility of Russian scientists at the different historical stages and tries to identify its effects on emergence of the scientific elite.

International mobility: definition of the concept and types

We are inclined to call territorial movements of scientists or research teams that involve other countries as an international mobility. When mobility involves a residence change it is worth using the term of migration. International mobility is divided into three basic types: pendulum mobility, irreversible migration, and migration with a feedback (Figure1). If a scientist has not emigrated, but works constantly in her country and works heavily for temporary contracts abroad, this type of territorial mobility may be called pendulum. If a scientist emigrated from her country and lost all ties with the original scientist community, this type can be called an irreversible migration, but when a scientist has preserved the ties, it is a migration with feedback. Scientists can just cooperate extensively with their colleagues in their original country through joint publications, exchange of literature, holding teleconferences, etc. They can be as well in charge of a laboratory in their country and from a distance of many thousands of kilometers coordinate team researches with the help of new information technologies paying several visits a year. This type of mobility encourages scientists to come back home and is a channel through which the latest scientific information can be brought into developing countries. The present-day science introduces many corrections to definitions of the mobility concept. If scientists’ emigration becomes huge, experts use the term brain drain. This type of mobility becomes a negative factor in the development of national science, because the ever growing volume of emigration threatens the very existence of either particular scientific field or science in general, in a region or country.

²⁶ The paper was prepared in the framework of the project «Scientist’s Mobility as a Mechanism for Integration of Country into the World Scientific Community: experience of India, Mexico, Russia», supported by Russian Foundation for Humanities, 10-03-00329a
Present-day strategies for the international mobility.

Today a lot of experts tend to adopt a new perspective on the scientific mobility. You can often find in articles this kind of question: a brain drain or brain gain? (Wagner, C., 2008). Of course, the pendulum type of international mobility does not create a loss of the human capital for a country. The two other types of international mobility, the irreversible migration, and migration with a feedback, involve a change of a scientist’s place of living. The International Labour Organization treats them as a loss of the scientific potential for a country, especially in the situation of the mass migration that transforms into the brain drain. According to the International Labour Organization, the developing countries lose up to 10 to 30 percent of human resource in science and technology (Lowell, B.L. & Findlay, A., 2001), and in some countries the migration flows are even more significant. Nevertheless, the International Organization for Migration (IOM) calls on the States to use the diasporas as the development agents (IOM, 2005) and gives examples of the countries that benefited from migration. Pal Tamas in his paper «The New Nomads-Life Strategies and Cognitive Styles of a New Generation of Scientists in Eastern Europe» (Asheulova, N. A. & Lomovitskaya, V. M., 2010) delivered at the conference “Migration Mobility of Scientists as the Mechanism for Integrating Russia Into the Global Scientist Community” said that the brain drain is not a scientific issue but a particular case of a more general problem that can be worded this way: the demand for high-skilled specialists grows faster than a country’s capacity to produce them. In 1960s, scholars discussed three issues related to the brain drain:

1. specialists should stay in their own countries,
2. if people emigrate it is bad for a country,
3. intellectuals always leave periphery for the center.

Later on, quite other opinion triumphed: if scientists leave, they create a market for education, and it is a positive trend. After that, another notion, the brain circulation, became popular. But all those views are rather of political nature, not of science studies. A certain dualism emerged: internationalists (all capitals must be free, moral judgments are senseless) and nationalists (human capital is not the
capital of free outflow-inflow). So what is the ratio between the inflow of financial capital and the outflow of human capital? The outgoing hands and brains bring direct and tangible capital inflow into the country. If one compares foreign investment in the developing countries and money transfer from the expat specialists to their relatives who stayed behind, the second thing grows faster and comes to be a more significant financial source than the direct investment.

The paper «Mobility or brain drain? The case of Mexican scientists» (Jiménez, Jaime, Escalante, Juan C., Rodríguez, Carlos, Ramírez, Jesús M., Morales-Arroyo, Miguel A., 2010:89-109) deals with the present-day strategies for the global mobility. The authors describe cases from the USA, EU countries, Korea, Canada, China, Japan that encourage repatriation of scientists, subsidy professional associations and networks of scientists who stayed and who emigrated. The Chinese government takes active measures to bring back their expat scientists, but does not change its policy of open doors for students. «It does not matter that not all students return to the country, so long as some do, even if it is less than half of them» (Tremblay, Karine, 2005:196–228). It is impossible to stop (to close the doors) the flow of student migration from the developing countries into the countries that are scientifically and technologically developed. More so that many developed countries are active in using various programs to attract foreign students, and they provide subsidies for education. A number of non English speaking countries offer study programs in English. A large part of programs in Denmark, Finland, Netherlands, and Sweden is adapted this way which makes possible to attract foreign students. Programs like this can be found in France, Germany, Switzerland and Japan but their number is small. More and more countries USA, Canada, Switzerland, France, Japan, Australia, New Zealand, Ireland, Germany and so on – provide the foreign graduates with jobs on graduation issuing work visas after their student visas expired.

What are now practices of benefiting from high-skilled emigration?

1. Scientific Diaspora networks - which came into existence with new communication and information technologies (examples of such networks: SANSA in South Africa and Caldas in Columbia) – produce the elite in their own developing countries. China has an established and well functioning scheme of interaction with the Diaspora. Forum of the Committee of100 27 is one of examples of its activity.

2. India, with a well developed university system, produces a lot of high-skilled specialists who obtain in emigration high and responsible positions in the most prestigious technology and research centers in the world, especially in the USA. It is these expats who play a strategic role in attracting investments for theoretical and experimental research in India, to boost industrial export, to establish medicinal and educational institutions.

3. An important mechanism of integrating expat scientists from developing countries is encouragement of the diaspora’s participation in projects carried out in their own countries.

International Mobility in Russia and the Scientific Elite Reproduction

Russia is the country whose history has seen all types of international mobility: free movement of scientists in 18-19th centuries, forced emigration in the 1920s, a complete isolation in Soviet times, mass emigration in the post-Soviet years, and now a return to the practice of the brain circulation and the use of international mobility as a mechanism of integrating Russia into the global scientific community.

27The Committee of 100 is a national non-partisan organization composed of American citizens of Chinese descent. http://www.committee100.org/
The Russian science emerged and benefited greatly from the international scientists’ mobility. The Russian Academy of Sciences was established thanks to a famous fact: a number of talented young scientists came to Russia which resulted in creation of the Academy and science itself.

Both emigration and immigration were common for the world professional community. The Enlightenment saw sort of competition between European monarchs in attracting famous scientists. So, Catherine II managed to invite Leonhard Euler to St Petersburg, one of the leading mathematicians of that time, member of the Berlin Academy of Sciences under sponsorship of Friedrich the Great.

Scientists, when expressing their findings in the universal language and neglecting, to a certain extent, the state frontiers, tried to find the most favorable conditions for their researches. Specialists were not afraid of changing their usual social and cultural environment and went to other countries to work. When studying and preparing for scientific work, a prospective researcher, as a rule, tried to learn, as much as possible, a wide range of scientific concepts, methods and methodologies, easily moving between universities and laboratories of different countries (Kolchinsky, E. I., 2003:202-216).

Beginning from the second half of the 19th century, Russian scientists started to go outside the country quite often to found there their own schools of thought. They were, just to mention a few of them, the 1908 Nobel prize winner Ilya Mechnikov, microbiologist S.N. Vinogradsky, sociologist and economist M. M. Kovalevsky, geographer P.A. Chikhayev, mathematician S.V. Kovalevsky etc.

The World War I put an end to the International of scientists, caused an outburst of patriotism and chauvinism in all countries. In Russia the first mass wave of emigration began.

Russia’s scientists experienced lives full of tragedies. Almost each Russian scientist faced a painful choice in 1918: to stay in the country devastated by the civil war or emigrate. Those who stayed felt all troubles of that time: persecutions, hunger, cold homes, infectious diseases, horrible working conditions. Some of them were executed during the pogroms or the years of the Red Terror. After the civil war, Russia’s scientist community had to adapt their priorities to the interests of government to get more funding for science. In the 1920s, many of them got a feeling that the authorities understood them and were ready for cooperation. However, a lot of scientists, who did not want to bow to the Soviet power, emigrated. In the autumn of 1922, the Soviet government deported from the country more than 200 people with members of their families. They were mainly higher education professors from various Russian towns. Among the intellectuals, declared dangerous for the regime, were sociologist P. Sorokin (he was number 1 on the list for the city of Petrograd), professor of mathematics D.F. Selivanov (head of Petrograd University), professor of biology M.M. Novikov (head of Moscow University), professor V.V. Stratonov (dean, mathematics department, Moscow University), B.P. Babkin (head of physiology department, Novorossiysk University) and others.

It should be remembered that the mass emigration of scientists from Russia in the post-revolutionary decade provided science of other countries with outstanding discoveries and inventions. Russian scientists abroad tried for a long time to maintain scientific ties with their colleagues at home, they started even to create a special Russian science in emigration (specialized organizations, philosophy clubs, etc).

The Soviet period of Russian science, starting from 1930, changed radically the international mobility of scientists. During the Great Terror, international scientific communication was almost forbidden, the renowned scientists, including the founders of the social history of science N.I. Bukharin and B.N. Gessen, were executed. During Khrushev’s ‘thaw’ period, cooperation involved mainly scientists from socialist countries (German Democratic Republic, Poland, Czechoslovakia). Until the end of the 1980s, there was a total control, exercised by the regime as well by the Academy.
bureaucracy. A comprehensive cooperation was impossible, most scientists in Leningrad did not even expect to go abroad or to be published there. Their contacts were reduced to correspondence, exchange of literature and occasional meetings at international conferences in the USSR.

Nevertheless, science obtained significant results even in the context of a totalitarian regime. Science and education formed a joint system and reproduction of the Soviet state’s intellectual resources relied on it. All Soviet infrastructure including administration, national health system, economy, etc., was dependent on it. Under strict party and state control, science was actually the only island where one could fulfill own creative projects more or less freely. Science recruited talented and ambitious young people, it enjoyed social prestige and was highly paid. Here one could see a real competition between scientific institutions, research teams and individuals. The science system in the USSR had the goal of doing research across nearly all the range of fundamental sciences and maintaining the leading roles. The number of scientists and the governmental financing in the Soviet Union were usually the highest in the world. Since the Second World War, the Soviet scientific community’s administrators were part of the ruling elite and enjoyed all privileges (Asheulova, N.A. & Kolchinsky, E.I., 2010: 95-129)

At that stage, cultivation and reproduction of the scientific elite was an integral part of that significant component of the scientific community’s self-organization as the school of thought. The schools of thought played a very important role in the Soviet science: the elite reached “maturity” there, and scientific work as a free activity could be done in the schools of thought (Lomovitskaya V.M. & Petrova T.A., 1995: 85-90)

The notion of school of thought was explored by many scholars but as a science-studies concept it was analyzed for the first time by M. G. Yaroshevsky (Dezhina, I.G. & Kiseleva, V.V., 2008:7). M. G. Yaroshevsky treated the concept of school of thought as the unity of education and research that led to the emergence of a scientist team with its own program goals. It was relationship between the teacher and pupil that characterized a school of thought (Yaroshevsky, M.G., 1977:42).

K.A. Lange distinguished between two types of schools of thought: classical and a research team. A classical school of thought was an informal scientific team that was forming around a famous scientist (Lange, K.A., 1977:269). Foreign scholars who studied the science system in the USSR said about the uniqueness of informal scientists’ networks. Linda L. Lubrano in her paper «The Hidden Structure of Soviet Science» (Lubrano, Linda L., 1993) says that «Soviet scientists took initiatives in establishing networks for the exchange of information and the pursuit of science. They gathered around informal scientific leaders; they collaborated with colleagues in other laboratories; they shared scientific equipment and supplies. Rooted in the science schools of the 19th century, informal networks were a natural part of the Russian scientific tradition. Different interests and talents of scientific leaders and their respective science schools, research groups, social circles, and professional cliques resulted in a pluralism of scientific elites».

Scholars noted not once that emergence and functioning of the scientific elite was impossible without that efficiently functioning institute – a school of thought “where the teacher generated and articulated the ideas and spirit of a school. Not only was the teacher a particular person but a collective scientist – a research team” (Lomovitskaya, V.M., Petrova, T.A., Fomin, A.S., 1994:38-40). The schools’ substantial heuristic potential, its efficient implementation raise prestige of schools of thought and is a major mechanism of attracting students.

In the Soviet Union, to become part of the scientific elite one had to work their way up the following ladder: an elite Soviet school – an elite Soviet institute or university – a leading research
establishment in the USSR or a chair at the university (Chepurenko A.Yu. & Gohberga L.M., 2005:30).

Since the elite institutions had bigger resources to do research in particular areas, a gifted scientist who started their career at these institutions, had bigger potential for a differentiated accumulation of advantages – the Matthew effect (Merton, R., 1988, 79: 606-623).

A postgraduate course at the Academy was the best way of training young talents for scientific work in future. Young people studied at the postgraduate school of the USSR Academy of sciences, worked in the same sector during their studies, obtained PhD and got up the scientific career ladder. The promotion mechanism involved: status of a leading specialist, head of research unit (section, laboratory, department), then he or she became famous, received distinctions, got elected member of the USSR Academy of sciences, corresponding member or academician which was accompanied by a high scientific status. That was the way the Academy system of generation continuity worked.

Social and economic transformations caused a lot of changes in the post-Soviet science. The school of thought was destroyed when the right to intellectual property emerged. With the schools of thought ruined, a very important tool of the scientific elite’s reproduction was also smashed.

New ways took the place of the old ones. The international mobility has become today a significant new reproduction tool of the scientific elite. The Russian scientists’ contacts with the world scientific community – negligible in the Soviet times – acquired new quality in the early 1990s. The international mobility proved to be one of the main ways of integrating the Russian science into the global scientific community. The Russian scientists’ participation in the international labor division enables them to solve such a difficult problem of the post-Soviet science as a generation change.

But the scale of the international scientific mobility in Russia cannot be compared with European and other countries and ought to be bigger. Russian scientists communicate mainly with their colleagues within Russia only. The growth of publications with foreign co-authors in 2008/1998 could be illustrative in this aspect (Figure 2). Russia lags behind most of scientifically advanced countries. The growth percent is low (13.8) especially if compared with China (356.5).

**Figure 2.**

Increase in the number of publications with foreign co-authors 2008/1998

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of publications with foreign co-authors</th>
<th>Increase,%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1998</td>
<td>2008</td>
</tr>
<tr>
<td>China</td>
<td>4228</td>
<td>19300</td>
</tr>
<tr>
<td>India</td>
<td>2022</td>
<td>5209</td>
</tr>
<tr>
<td>UK</td>
<td>18360</td>
<td>33948</td>
</tr>
<tr>
<td>USA</td>
<td>43254</td>
<td>78348</td>
</tr>
<tr>
<td>Germany</td>
<td>19869</td>
<td>33541</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>Russia</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Value</td>
<td>15293</td>
<td>6865</td>
</tr>
<tr>
<td>Value</td>
<td>25097</td>
<td>7809</td>
</tr>
<tr>
<td>Value</td>
<td>64,1</td>
<td>13,8</td>
</tr>
</tbody>
</table>


Russia has seen several measures to encourage Russian scientists’ mobility and programs are drawn up to attract Russian scientist emigrants to cooperation in science (Dezhina, I.G. & Kiseleva, V.V., 2008:103). The Russian government’s initiative of founding a network of research universities can be regarded as a tool of the state’s policy. There are annual competitions among universities to obtain a national research university status for a period of five years. The universities receive additional funding from the government. It is expected that Russian expat scientists will choose those research universities if they decide to come back. All these measures will ensure that in 10 to 15 years the national research universities appear on the list of 500 top universities in the world (Dezhina, I.G., 2010:3-26).

The new federal target program “Scientists and educators of the innovative Russia in 2009 to 2013”, section 1.5 should encourage expats to return. The analysis of the main results in 2009 showed that 380 applications were submitted to the competition and 110 state contracts concluded. Those invited were mainly professors (36), laboratory heads (28), and senior researchers (18). Each fourth of them works now in the USA (28), 18 in Germany and 15 in France. More than half of the Russian teams who passed the competition were representatives from universities or institutes. 38 percent were the Academy institutions. Half the Russian winners were located in the Central federal district28. The results of these initiatives are so far insignificant, it needs time to assess their implementation.

Russia’s joining the Bologna process in 2003 facilitates consecutive reforms in Russia’s higher education: transition to a multilayer system (baccalaureate and a master's degree), introduction of the credit system, and a standard attachment to a diploma has a positive effect on the international academic interaction. Mobility is based on exchange agreements between universities, and Russian teachers and students do their researches in foreign research centers. Many non English speaking countries are active in using various programs in English to attract foreign students. But you can hardly find programs in English in Russia which leads to the fact that mainly Russian speaking students from the Commonwealth of Independent States come to study in Russia.

The principal tool of training young researchers is a postgraduate course. Russia ought to modernize its postgraduate schools. They should correspond to international ways of obtaining PhD. For example, they can be partially modeled on American graduate schools. They feature a set of advanced academic courses and seminars with both academic and research components. At graduate seminars in American universities, graduates discuss their researches under guidance of professors. These are special advanced trainings on research methods. Graduates also take part in research projects, in scientific work. American graduates, nevertheless, receive normally grants big enough to work on their dissertations without looking for additional money outside university, and doing their research in free time. But in Russia it is a norm. Besides that (and it is rather a European experience, not American), postgraduate course should contain internships in foreign countries. It is seen as an absolutely necessary part of a postgraduate’s training. Now all kinds of educational programs in
Europe include exchange between universities and special grants to encourage postgraduate mobility, and participation in international conferences at the European level (Gelman, Vladimir, 2009:5).

Today the scientific elite reproduction in Russia has seen some negative trends: young people are reluctant to work as researchers. Several reasons can be mentioned: low starting salaries, inadequate research facilities where it is impossible to reach findings at the world level, uncertain career prospects, and so on.

It also happens that young talented researchers are unable to find jobs at Russian institutions. Academician G. Georgiev gives an example of his Institute of gene biology, Russian Academy of Sciences where all departments conduct researches at the world level and more or less supported with grants. Upon defending a dissertation, young gifted scientists seek to go on working at the institute and not leaving the country. But there are no enough vacancies for young people (Georgiev, Georgy, 2009).

Minister of education and science Andrey Fursenko discussing plans for rebuilding the country’s research base with “Nature” has said: “Our goal is to provide the entire Russian scientific community with equal opportunities to expand international links and to create partnerships that are not limited to a handful of demonstration projects at elite universities” (Schiermeier, Quirin, Severinov Konstantin, 2010:858).

Conclusions

1. Russia is a country whose history illustrates all types of international mobility: free movement of scientists in 18-19th centuries; forced emigration in the 1920s; complete isolation in the Soviet times; mass emigration of scientists in the post-Soviet period; and at last a return to the practice of brain circulation and the resort to the international mobility as a mechanism of integrating the country into the global scientific community.

2. The existence of elite scholars is a necessary condition for the functioning of science. The career paths of the Russian scientific elite changed dramatically in comparison with Soviet times. Research and education in the Soviet Union formed a single system that influenced reproduction of the intellectual resources in the Soviet state. The scientific elite normally rose up the following ladder: an elite Soviet school – elite Soviet university or institute – a leading USSR research institution or a university chair. The Soviet science recruited talented and ambitious young people and enjoyed a high social prestige and high salaries. In the Soviet Russia, the emergence and reproduction of the scientific elite was inextricably connected with a significant self-organizing element of the scientific community known as a ‘school of thought’ (nauchnaya shkola). The school of thought played a very important role in the Soviet science: not only the elite “reached maturity” there, but scientific work itself as a free activity could be fulfilled in a school of thought.

Now Russia has seen negative trends in the scientific elite reproduction: the youth is reluctant to work as scientists, people at the age of 30 to 40 leave scientific jobs. The main reasons are: low prestige of the scientific occupation; negative public image of a scientist; postgraduates’ low grants and small initial salaries for interns and junior researchers, especially compared with what the private sector can offer; inadequate research facilities; underdeveloped system of science foundations; uncertain career prospects; unresolved issue of living conditions, and so on.

In the post-Soviet period, schools of thought as a form of the scientific community’s self-organization were destroyed, and with destruction of schools of thought a very important tool of the scientific elite reproduction was smashed. Today the international mobility becomes a new significant tool of the scientific elite reproduction. But the scale of the international scientific mobility in Russia
does not match what can be seen in the world. Besides that, Russia has seen several measures to encourage Russian scientists’ mobility and programs are drawn up to attract Russian expat scientists to collaborate in science. The results of these initiatives are so far insignificant, time is needed. Russia ought to modernize its postgraduate schools. They should correspond to international ways of obtaining PhD. The Russian scientists’ participation in the international labor division enables them to solve such a difficult problem of the post-Soviet science as a generation change.

In general, it should be noted that the academic mobility in Russia became an integral part of the Russian scientific community’s process of entering the global educational and scientific space. It facilitates recognition of the Russian science, helps Russian researchers to overcome the national isolation and enter the European and global labor market.

A number of problems standing in front of young scientists in Russia can be solved in the context of integration into the global science. Participation in joint projects, international scientific events, publication of research findings in prestigious journals, internship in famous scientific centers in Europe and the USA, receiving grants from foreign foundations – all this leads to wider experience, young specialists’ higher status, and it opens up new opportunities in their own country.

References:


Dr. Darryl Macer
Building infrastructures to better ensure ethical science policy

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What future do we want? How can we reach that? The societal and policy infrastructures to guide the development of wise and ethical science need to be carefully constructed to utilize the creativity of humankind expressed in the scientific endeavour. The pursuit of a good life is a goal that all persons can hope for. We can consider the four imperatives of love for ethical science, as self-love, love of others, loving life and loving good. Love is not only a universally recognised goal of ethical action, but is also the foundation of normative principles of ethics (Macer, 1998). The love of good, beneficence is the foundation of the public enterprise of scientific research. Global responsibilities for promotion of good for all (not only humankind) is necessary for our sustainable future.

Modern technology has been a catalyst to reawaken social interest in ethics, but do we need a new ethics to cope with the challenges of modernity and globalization? The underlying heritage of ethics can be seen in all cultures, religions, and in ancient writings from around the world. Ethics is learning how to balance different benefits, risks and duties. In recent decades renewed impetus has been given to ethics through its application to consider the challenges of new technologies in life sciences and medicine. Bioethics includes ethical issues related to all branches of knowledge, including the environment, life sciences, and medicine and associated technologies. Concepts of bioethics can be seen in literature, art, music, culture, philosophy, and religion, throughout history. Their integration into policy making has been expressed in various mechanisms.

UNESCO is the UN agency charged with investigation of bioethics, and has taken up some of the ethical challenges raised by advancements in biomedicine and life sciences in the Ethics of Science and Technology Division of UNESCO. The programs initiated formally in 1993 with the establishment of the International Bioethics Committee (IBC) were a response to the global calls for bioethics debate and discussion, including establishment of programs in bioethics education and of ethics committees. The implementation of international standards in ethics of science and technology and bioethics is important, and there are three International Declarations on Bioethics unanimously accepted by member countries at the UNESCO General Conference (Universal Declaration on the Human Genome and Human Rights, 1997; International Declaration on Human Genetic Data, 2001; Universal Declaration on Bioethics and Human Rights, 2005).

The Declarations address a wide range of decision-makers and actors - including individuals, professional groups, public or private institutions, corporations or States. Regional and National workshops and seminars to increase knowledge and awareness of these Declarations for Policy Makers, Parliamentarians, health care professionals, academics and civil society groups, are being conducted. The programmes in the 47 countries in the Asia-Pacific region, are coordinated through RUSHSAP at UNESCO Bangkok.

The United Nations has been instrumental in the development of the fundamental principles of human rights, and this is the common language of the three UNESCO Declarations. The importance of
reconciling and inter-relating the different aspects of bioethics in these Declarations is that if we attempt a common statement of the understanding of bioethics we need to have many items included. A common focus is on the issue of human dignity, and a common starting point has been in the internationally agreed principles of human rights law. This concept can be debated, but there are some clear examples of abuse. It is to be hoped that these Declarations will encourage and promote greater awareness amongst people and bodies making bioethical decisions and carrying out such practices.

Moral dilemmas are faced in a range of professions including all fields of science and technology. Critical thinking capacity is essential for empowering persons to cope with changing times. Participation can promote the creation of ideas and individuality, which we all need in the era of globalization. Sound policy and policy review is also essential for sustainable science policy and use of the results of science. Despite the unanimous acceptance of international declarations relating to ethics of genomics and human rights in UNESCO, and related international instruments by other UN agencies, there are gaps in the implementation of these standards into national laws and guidelines in many countries.

To help us consider the responses that may assist policy formulation in the future, let us examine some of the cultural background and challenges in the Implementation of the most recent declaration, the Universal Declaration on Bioethics and Human Rights, especially with regard to Asia and the Pacific. Ethics is a concept balancing benefits and risks of choices and decisions. The underlying heritage of ethics can be seen in all cultures, religions, and in ancient writings from around the world. We in fact cannot trace the origin of bioethics back to their beginning, as the relationships between human beings within their society, with nature and God, are formed at an earlier stage than our history would tell us.

There are at least three ways to view ethics:

1. Descriptive ethics is the way people view life, their moral interactions and responsibilities with others in their life. Information we gather is used to describe many things, and there are many ethical issues related to gathering information and storing information.

2. Prescriptive ethics is to tell others what is ethically good or bad, or what principles are most important in making such decisions. It may also be to say something or someone has rights, and others have duties to them. It is related to policy making and law.

3. Interactive ethics is discussion and debate between people, groups within society, and communities, and clearly information ethics is central to shaping the types and forms of interactions that are possible.

We could take many examples of bioethics debates in different cultures, which illustrate the approaches to ethics in a range of environmental and medical ethics issues. These issues have led to a variety of debates, and some of these also were topics that were discussed in the debates leading to the Declaration on Bioethics. Some issues are regional while others relate to the recent globalization of approaches to bioethics, the expansion of respect for human rights, and the shift towards individualism away from communitarian ways of approaches to ethics.

The rapid progress of medical technology has led to challenges in the way that medicine is practiced in all cultures. The existing systems and patterns that are seen in the relationships between patients, families, health professionals, and the society in general changed. At the same time, as technology was transferred, some values were also imported beyond the general acceptance that new technology must be better than old. A number of countries in Asia and the Pacific were colonized, and
a few communities and Islands exist still as colonies, which has significantly influenced their values and the practice of medicine.

One of the current issues in cross-cultural ethics is whether respect for individual autonomy and informed consent should be universal, and who should be told the truth about medical diagnoses first? How do we deal with new diagnostic avenues, such as mail order genetic tests and HIV screening? When the change in public opinion on the desire to be told the truth about their disease actually occurred? In fact, whether there was a change in this desire to know what was happening at all, is unknown. It could have been merely a recognition of civil rights that acknowledged this desire to know what was happening, and there may not be any change in desire to know what is happening from the patient's perspective over past decades. The patients are more able to express themselves now.

From the results of the International Bioethics Survey conducted in 1993 in 10 countries in the Asia Pacific Region (Australia, Hong Kong, India, Israel, Japan, New Zealand, the Philippines, Russia, Singapore, Thailand), we can see many people perceive simultaneously both benefits and risks from science and technology (Macer, Bioethics for the People by the People, 1994). The diversity of reasoning exposed in the survey on a variety of questions was independent of education or age, and similar diversity of reasoning was found among members of the public, high school biology teachers, and scientists. The overall statistical results are similar to results of surveys in Australasia, Europe, India, Russia, Thailand and the U.S.A.

We need in-depth cross-cultural dialogue and study rather than defining one ethics as correct and one as not. However, all countries of the world have endorsed the UDBHR, which outlines a common framework of principles for application of ethics to a broad concept of bioethics.

The declaration includes a series of principles including:

1. *Human dignity and human rights*
2. *Benefit and harm*
3. *Autonomy and individual responsibility*
4. *Consent*
5. *Persons without the capacity to consent*
6. *Respect for human vulnerability and personal integrity*
7. *Privacy and confidentiality*
8. *Equality, justice and equity*
9. *Non-discrimination and non-stigmatization*
10. *Respect for cultural diversity and pluralism*
11. *Solidarity and cooperation*
12. *Social responsibility and health*
13. *Sharing of benefits*
14. *Protecting future generations*
15. *Protection of the environment, the biosphere and biodiversity*
UNESCO does not define one bioethics as correct and one as incorrect. Rather the Declarations provide a framework for rediscovery of indigenous traditions, and the development of appropriate cultural responses to new issues raised by science and technology in every culture. These principles are an ethical framework for building policy on science and technology in all areas.

The interesting point for cross-cultural ethics is at what point do you call something distinctly “Malaysian” or “Asian” or “Tongan” or “Turkish”. Given that there are numerous ethnic groups even inside one country, especially as vast as Indonesia, there is obviously much opportunity for extensive anthropological and sociological studies of the bioethics of each community. Through the UNESCO Asia-Pacific School of Ethics, which includes over one hundred diverse partners in the delivering of bioethics objectives expressed in the UDBHR, UNESCO works to investigate the way that each community reasons about bioethics and applies their principles of bioethics to particular issues.

The majority of the world's population live in Asia, the popular international religions of the world originated in Asia, and the world’s largest English-speaking country (India) is in Asia. Considering this, we may ask why there have hitherto been so few papers from Asia published in most journals dealing with medical or environmental ethics. While the economic centre of the world has been shifting to Asia, and most people are using products made from Asian-based companies, few papers in bioethics have been written from Asia. Therefore we should also try to encourage academic research on ethics, and especially that research which may provide useful results that will lead to more sound policy.

One approach for future study is exploring the question of how traditional views can be applied to modern dilemmas. Have fundamental principles of ethics changed over time? There was more beneficence a century ago but now there has been more precedence given to autonomy in textbooks, but is this true in wider society? As for the importance of justice and non-malfeasance the trends in different localities are more difficult to determine. Autonomy comes with individual responsibility as outlined in the UDBHR.

Especially in Asia and the Pacific, "bioethics" includes medical ethics, environmental ethics and issues raised by science and technology. There was a long heritage of examining these issues found in all cultures, with a range of anthropocentric, biocentric, and ecocentric views. Asian and Pacific cultures are more bio-centric than many Western cultures. Feedback from the region comes through the UNESCO Asia-Pacific School of Ethics, which anyone with the willingness to be involved in research and activities with UNESCO is welcome to join, as well as regional members of UNESCO Ethics Committees.
In 2005 the International Bioethics Committee (IBC) in Tokyo and the World Commission on the Ethics of Science and Technology (COMEST) in Bangkok, both had their meetings in the Asia and the Pacific region. There was also feedback from other experts on specific consultations with experts in meetings, and the development of regional networks. The Asian Bioethics Association emerged from the nascent East Asian Association for Bioethics at the UNESCO Asian Bioethics Conference in Kobe in 1997, and the Ninth Asian Bioethics Conference (ABC) will be held in November 2008 in Indonesia. Like the 2007 ABC in Bangkok, it will be held in cooperation with UNESCO.

The Regional Unit in Social and Human Sciences for Asia and the Pacific (RUSHSAP) in Bangkok was also providing opportunities for cross-cultural dialogue and feedback from ongoing pilot projects in the regional ethics network through larger meetings such as the UNESCO Bangkok Bioethics Roundtables, and networking meetings with focus on developing specific projects for implementation, held in a variety of places since 2005 (including Bangkok, Karachi, Islamabad, Bangalore, Vellore, Chennai, Delhi, Mumbai, Kerala, Madurai, Colombo, Tokyo, Kumamoto, Yokohama, Seoul, Apia, Suva, Hanoi, Sydney, Canberra, Jakarta, Yogyakarta, Beijing, Shanghai, Dhaka, Phnom Penh, Auckland, Manila, Kuala Lumpur, Kota Bahru). We plan to hold many more meetings in Asia and Pacific Island states in collaboration with local partners, and each of these can provide guidance on the development of better infrastructures for local, and national policy towards more ethical science and technology.

There is an existing mandate for the education and establishment of ethics committees as can been seen in the "Universal Declaration on the Human Genome and Human Rights" unanimously approved in mid-November, 1997 at the General Conference of UNESCO. There is also a strong basis for establishing ethics committees. There is also universal support for some common principles of bioethics as seen in the articles of the 2005 Universal Declaration on Bioethics and Human Rights.

In conclusion, there is an existing basis for developing bioethics in all regions of the world, and UNESCO will work with those in every culture to help elaborate bioethics for the people and by the people. New fields for discussion are being added, such as Neuroscience and Neuroethics, and in broad definitions of bioethics as taken by the UDBHR in article 14 on social responsibility which includes recognition of the right to food, water and minimum standards of living.

The 2005 Declaration on Bioethics importantly contains clauses on social responsibility, and the need to apply bioethics into practical spheres. The real urgencies of contemporary science policy ethics include access to healthcare, to adequate nutrition and drinkable water, to the reduction of poverty and illiteracy, the improvement of living conditions and the elimination of unjust marginalisation of individuals and groups. Because this is the real world in which bioethical issues must, in most countries, be resolved, it is necessary to include reference to these concerns and to the duty of all those who make decisions and carry on practices relevant to bioethical issues, where relevant, to address and be conscious of such urgent and practical considerations.

The Regional Unit in Social and Human Sciences in Asia and the Pacific (RUSHSAP) at UNESCO Bangkok also launched the Ethics of Energy Technologies in Asia and the Pacific Project in September 2007. In 2009 the project name was changed to Ethics and Climate Change in Asia and the Pacific (ECCAP) project, and there are 17 working groups. The first few reports from this project are published (Boonlong et al. 2011; Kanaly et al., 2010; Rai et al. 2010), and many other reports are available as drafts for open feedback on the website. [http://www.unescobkk.org/rushsap/energyethics].

The 17 working groups below are open to further members and suggestions:
The aim of the working groups is to develop dialogue around these particular issues with a focus on environmental ethics and human security. Each group will produce a report with policy options that can be used by policy makers, philosophers, scientists and researchers to consider the ethical dimensions of energy policy. These reports are developing infrastructure on science policy in particular areas, as well as transdisciplinary and multicultural networks. There are over 200 persons who are currently members of the working groups, from young and old, many disciplines, professions and country. To facilitate discussion and information sharing between project participants, a Yahoo Group is also used: [http://groups.yahoo.com/group/unesco_eet/](http://groups.yahoo.com/group/unesco_eet/)

Such concepts are actually coming back to the ancient heritage of ethics to help those in need in the society, in a broader perspective including housing, food, water and sanitation. The whole person and a healthy society must be aided, and infrastructures such as national research councils, universities, government and private think tanks, can guide better review of science policy. Bioethics includes social ethical issues such as child labour, body shape. In this way as we apply bioethics into public policy in different cultures it may catalyse the discussion of a range of issues. This broadened scope of bioethics should also apply to research and teaching. The societal and policy infrastructures to guide the development of wise and ethical science need to be carefully constructed to utilize the creativity of humankind expressed in the scientific endeavour.
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The documents cited in this paper and background material on Asian bioethics can be found at the websites:

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<http://www.unesco.org/shs/ethics>

<http://www.eubios.info>
Migration of the Highly Skilled from Pakistan and Bangladesh and its Impact on Technological Development and Economic Growth

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Introduction

The dynamics of globalization has been characterized not just by the international flow of capital, commodities, goods, services and information but more so of labour. The global labour market, particularly for the highly skilled\(^1\) is expanding. According to a study by Docquier and Marfouk (2006) on OECD countries, the migration of the highly skilled from developing countries is rising. The study reveals that out of 59 million migrants in OECD countries alone, 20 million are highly skilled. Migrants in OECD countries of Canada, USA and Australia with tertiary level qualification reflect colonial and linguistic ties with dominance of South Asian countries including India, Pakistan, Sri Lanka and Bangladesh.

The knowledge-intensive economies of the developed countries are expanding to absorb more knowledge workers and are competing for foreign scientists and engineers. Several countries are offering scholarships and other incentives (such as extended stay after completion of higher studies) to attract bright young foreign students. Some other incentives include programmes such as H1-B visa programme in the United States, Green Card scheme for information technology experts in Germany, introduction of the Highly Skilled Migrant Programme in the United Kingdom and Australia. Developing countries such as Pakistan, Bangladesh, India and China, which are major contributors of highly skilled migrant workers particularly scientists and engineers, are confronted with challenges of directing additional resources to higher education to increase access (often at the cost of compromising quality) and to offer higher salaries and other incentives in order to retain a critical number of scientists, engineers and other professionals at home.

Scientific communities are more international in scope than other professionals. The quest of scientists for continuous learning and to keep themselves abreast with the current frontiers of knowledge keeps them mobile till they anchor themselves in a knowledge hub. The foremost priority for migration of scientists has been identified as the desire to be part of global knowledge networks. Most of these networks are concentrated in developed countries of Western Europe, USA and Eastern Asia led by Japan. These networks comprising scientists from developed and developing countries hold the potential of helping the developing countries build their scientific capabilities (Tim Turpin, 2007). Some developing countries such as India and China have realized this potential and are offering attractive incentives to engage their Diaspora in their development programmes.

Developing countries require a critical mass of highly qualified scientists, engineers and other professionals to attain socioeconomic progress. High quality professionals are needed not only for industrial growth and competitiveness but also for provision of social services such as health, sanitation, energy, transport and information technology infrastructure, education and agriculture. Migration of scientists, engineers and medical professionals is generally known to bear a negative effect on a country's economic and social development. Source countries lose out not only on the
investment they have made on training highly skilled people but are often forced to hire foreign consultants to meet specific development needs at a high cost to tax payers.

This paper provides a brief review of literature on migration and maps trends of migration of the highly skilled scientific personnel in Bangladesh and Pakistan. It reviews impact of migration in terms of institutional weakness to plan and implement projects related to building of local technological competence and the resulting economic implications. The current state of technology capacity is assessed using standard input and output indicators and comparisons are made with fast developing countries of India and China. Conclusions draw attention towards much needed policy interventions for arresting migration and for engaging the Diaspora to help reform institutions, technology transfer and promotion of knowledge based entrepreneurship.

**Literature review**

Early literature supports the view that skilled migration is unambiguously detrimental and is a negative externality on the population of the source country (Bhagwati & Hamada 1974; Grubel & Scott 1966; Johnson 1967; Kwok & Leland 1982).

Ite (2002) has discussed that migration with a high level of human capital is detrimental to the country of emigration. The loss of skilled human resources will ultimately have a grave effect on the economy and may jeopardize development.

Recent brain drain literature suggests that impact of brain drain could be positive on human capital and growth in the source countries (Beine et al 2003; Beine et al 2001; Docquier and Rapoport 2004; Mountford; 1997 Stark et al 2004; Stark 2004, Stark et al 1998; Stark et al 1997 Stark and Wang 2002; and Vidal 1998). Their work is based on the assumption that if return to education is higher abroad than at home, the possibility of migration increases the expected return of human capital, thereby enhancing investment in education in the source country.

Schiff (2005) has discussed a number of factors that are not taken into account in new literature while assessing brain gain from brain drain. The author argues that if education is provided mainly through public investment in the source countries, this will require additional funds that could be raised by authorities in the form of increased taxes, reduction in educational subsidies or reduction in other public expenditure. Tax increase will reduce the demand for education and reduction in educational subsidies will raise the cost of education. These actions may result in a smaller brain gain. In his opinion, the impact of brain drain on welfare and growth is likely to be significantly smaller, and the likelihood of a negative impact on welfare and growth significantly greater than reported in new literature.

The phenomenon of “Brain Waste” was introduced by Mattoo, Neagu and Ozden (2005) in their study of highly skilled immigration to the United States. This refers to the fact that foreign workers are often hired for jobs for which they are overqualified. Examples of Caribbean doctors or Eastern European scientists working as taxi drivers in some large US cities are well known. Similarly, Moroccan doctors in France are typically working in less skilled positions (e.g. as interns) with significantly lower salaries (Schiff 2005).

According to Ghose (2002) freer movement may lead mainly to more skilled migration between and towards developed countries with a positive impact on their economic growth and an increase in the scarcity of such human resources in developing countries with all the risks this holds for their economic and social progress. According to the United Nations, the departure of health workers from some African countries such as Nigeria has seriously impeded the delivery of health services to the local population. If this trend continues unabated this would undermine the progress
that has to be made to achieve the health-related Millennium Development Goals (Global Commission Report on International Migration, 2005).

The engagement of the Diaspora in national development programmes is known as “Brain Circulation” and several authors have described these knowledge networks as an invaluable resource both for host and source countries. Brain Circulation has helped countries such as India and China, the world’s two largest contributors of highly-skilled emigrants. These countries have made long term sustained investment in science and technology and developed some world class institutions to train high quality scientists and engineers. Diaspora networks have acted as bridges by providing access to technology, markets, sources of investment, and expertise. These networks have also acted as source of policy expertise and for managerial inputs. The emergence of regional knowledge hubs such as the information technology hub in Bangalore and Biotechnology hub in Hyderabad, are cited as the best examples of Brain Circulation from the Indian Diaspora working in the Silicon Valley and other developed countries of the European Union and USA. East Asian countries such as South Korea and Taiwan have also used their Diaspora Networks for technology transfer, institutional reforms, entrepreneurship and business development (Kevin O'Neil, 2003).

Migration trends in Bangladesh

The People’s Republic of Bangladesh is among the most densely populated countries in the world with a high poverty rate. With a population of over 161 million and a GDP of US$83.04 billion, [per capita GDP approximately US$1600 (PPP)]. Bangladesh has been classified by UNCTAD amongst 80 Least Developing Countries (LDCs). However, per-capita (inflation-adjusted) GDP has more than doubled since 1975 and poverty rates have fallen by 20% since the 1990s. Much of the growth in GDP has been driven by thriving textile, processed food and generic pharmaceuticals sectors.

Bangladesh is labour surplus and therefore has been actively participating in supply of labour (unskilled, semi-skilled and skilled) to the global market. The government has supported international migration of labour as development policy to achieve following objectives: reduce supply side pressures on employment; address issues related to extreme poverty thus improving economic conditions of migrants and increasing the capability of their families to engage in entrepreneurial activities; and to help transfer of technology through skills acquired abroad by migrant (Nur-ul-Islam).

According to the Bangladesh Bureau of Migration, Employment and Training (BMET), during 1976-2007 about 6.57 million citizens left the country for employment abroad. Year-wise migration trends are given in figure 1. This indicates a steep increase in the number of migrants from 1991 onwards. The distribution pattern of migrants shows that most (45%) are working in Saudi Arabia, followed by UAE (17%) and Malaysia (10%). The favourite destinations among professionals are UK, Australia and USA (figure 2). Migration choices are based on demand in host countries and the skills possessed by migrants (Tanveer and Zainab, 2009).

Bangladesh migrants have been classified in four categories as skilled, semi-skilled, unskilled and professionals. Doctors, engineers, nurses and teachers are considered professional workers, production workers and computer operators are considered as skilled, tailors and masons as semi-skilled and household workers, agriculture workers, hotel and cleaning staff are considered unskilled. Migrants comprise 50% unskilled, 31% skilled, 16% semi-skilled and 4 percent professionals. This means 0.26 million doctors, engineers, teachers and nurses have left the country. This is a huge number considering the investment the country made in training of these professionals and the demand of their services for domestic social and economic development.
Migration trends in Pakistan

Over the years, Pakistan has witnessed increasing trend of migration of its skilled professionals. According to the Ministry of Overseas, Pakistan, approximately 7.0 million Pakistani nationals reside outside their country, out of these over 4.0 million have legal status and the rest are non-registered migrants including students who have overstayed their status. Pakistan is the 6th most populous country of the world. High unemployment, political and economic instability, security issues, weak institutions and inflation rates are among the push factors responsible for international migration (Ahmed 2008). Figure 3 shows total number of semi-skilled and highly skilled manpower that emigrated from Pakistan. The total skilled manpower which emigrated during 1971 -2000 i.e. in a period of 29 years was 2.88 million. This number has soared to 4.55 million during 2001-2008 (during a period of eight years). Among these 44,360 were highly skilled migrants, including doctors, engineers, scientists and technical experts (figure 4).

Figure 5 shows the distribution of migrants by destination. About 1.9 million (47%) reside in the Middle East, followed by 1.0 million (28%) in Europe; 0.85 million (21%) in USA; 0.073 million (2.0%) in Asia and Far East; 0.038 million (1.0%) in Africa and 0.023 million (1.0%) in Australia and New Zealand, and the rest in other countries. Trends of migration (2001-2008) (figures 3 & 4) show that ratio of skilled and unskilled migrant has changed since 1970 with migrant population comprising a higher number of highly qualified doctors, engineers, IT specialists and other professionals. Another reason of increase in the number of highly qualified migrants is the tendency of foreign students to stay abroad for work rather then returning to their homeland. According to National Science Board “Science and Engineering Indicators” (2008), USA, the enrollments of foreign students in the graduate engineering programmes offered by US universities more than doubled from 9,300 (35% of enrollment) to 21,400 (55% of enrollment). Students from China, Greece, India, and Pakistan accounted for most of the increase in foreign graduate engineering enrollments.

Since 1970, the government of Pakistan has adopted a policy to encourage emigration of unskilled and semi-skilled manpower. In the 1970s and 80s, Pakistan exported large number of unskilled manpower mainly to get relief in unemployment as the country faced war and external threats. The migration of highly skilled and professionals has increased significantly since 2001, despite relative political stability and economic growth during 2001-2007.

Remittances and Brain Loss

It is generally argued that migrants make valuable contributions to the countries of origin by sending remittances in foreign currency which form a significant part of GDP of developing countries. Remittances are considered to be a huge economic benefit of migration for the source country as developing countries require foreign exchange for debt repayment, import of capital equipment for industrialization and boosting foreign exchange reserves. Remittances help reduce poverty, income inequalities and provide capital for investment in education and entrepreneurial activities.

Remittances comprise 10 percent of Bangladesh’s GDP and have been rising over the years (figure 6). The amount earned through remittances is five times higher than the country receives as Overseas Development Assistance (ODA) and ten times higher than Foreign Direct Investment (FDI). According to a recent UNDP study by Juan Buchenau remittances of migrants from Bangladesh has helped reduce poverty by 6.0 percent.

Remittances also continue to form an important component of Pakistan’s GDP. Figure 6 shows the increasing trend of remittances received by Pakistan since early 1970s. Over the years remittances have gradually increased from just US$1.0 billion in year 2000 to over US$6.0 billion in year 2007 for
both countries. Real GDP growth is positively related to workers’ remittances during 1972-73 to 2002-03 (Iqbal & Sattar, 2005).

While migration of unskilled and semi-skilled may temporarily provide relief to the economy through remittances, it has been well-established that if remittances are not spent on education and training of scientists and engineers and for industrial developments to create new jobs at home, migration may have a negative social and economic impact on the population of source countries.

Stahl & Habib (1989) show that though remittances in countries like Pakistan and Bangladesh are mainly spent on the consumption of goods or construction of houses, this ultimately leads to the expansion in the demand for intermediate goods and employment generation which contribute to the economic development of these countries.

The empirical studies on the pattern of expenditure out of remittances indicate that a considerable proportion is spent on non-tradable goods such as land, housing and education (Connell, et al., 1976, Connell, 1980, Lipton, 1980, World Bank 1981).

Several authors have attempted to calculate the benefits of remittances but there is a need to factor in a number of countervailing issues. Chami (2005) finds robust negative correlation between remittances and GDP growth. This indicates that remittances do not serve as a source of capital for economic development. Locus (2008) has discussed that long-term dependence on exporting labour in return for remittances can be risky and costly. There are dangers of over-dependence on the migration—remittances nexus. The impact of remittances on the economy also depends on the use of remittances.

While remittances have helped poverty reduction for families of low-skilled migrant workers in general, it is observed that highly skilled migrant do not contribute in any significant manner towards remittances. They maintain better quality of life in host countries and educate their children in expensive institutions abroad.

Migration of the highly skilled and its impact on institutions responsible for technology development and economic growth

Pakistan has established large number of institutions for technology development and to help process of industrialization. At the discovery level, universities in Pakistan have increased from 54 in 1999 to almost 133 in 2010. Most new public and private universities or colleges are, however, operating on low research budgets and with very few highly qualified research and teaching staff. With the continuing exodus of large number of highly skilled only 22 percent of university faculty has Ph.D level qualification (report of Higher Education Commission, 2002-2008). A small number of the highly qualified university faculty is thinly distributed among several public and private universities with the resulting deterioration in quality of teaching and research.

Pakistan has also established large number of R&D institutions to help industry absorb imported technology or to convert university research into prototypes for commercialization. Out of 166 R&D organizations about 60 percent work in the field of agriculture, most are small research stations located in different regions of Pakistan. During the 1960-70s agriculture research was accorded priority which resulted in increased productivity of all major crops by 3-4 fold bringing about a Green Revolution. After the 1971 Pakistan, India war and the separation of Bangladesh, public research priorities shifted to defence research. Consequently funding for civil research including agriculture research was drastically reduced. The agriculture research institutions were deprived of requisite funding for research and for hiring skilled researchers. The salaries of highly skilled
agriculture scientists as well as their career advancement remained stagnant for several years. Consequently, premier research institutions such as the Ayub Agriculture Research Institute in Faisalabad which had discovered hundreds of new varieties of grains, vegetables and pulses, lost all its PhD researchers to Canada and other developed countries. (Source: interview with Dr. Gulam Rasul, former head of Ayub Agriculture Research Institute).

Pakistan Council of Scientific and Industrial Research (PCSIR) is one of Pakistan’s largest research establishment with 14 research laboratories located in different provinces. PCSIR efforts in the past reduced some dependence on foreign technology but most of its indigenous technology generation efforts remain under commercialized. PCSIR had more PhD scientists on its roll in 1980 than in year 2009. The exodus of highly skilled personnel has resulted in gradual decline of PCSIR which had filed more patent applications before 1980 than in later years. (Source: Report on Pakistan’s Technology competence Building, 1998). Similarly other R&D institutions established to help the process of technology development and industrialization such as National Institute for Electronics, Pakistan Council for Research in Water Resources, Pakistan Council for Research in Renewable Energy Technologies have lost their highly skilled personnel to the developed countries (Source: Author).

Realizing the extreme shortage of high quality research and teaching manpower to implement its technological development programmes, the Ministry of Science and Technology in 1986 launched a programme for development of high quality manpower. Almost 1800 brightest students were selected on merit and were provided government scholarships to study in the top institutions in USA, UK and other developed countries. The cost of the programmes was US$70.0 million. Almost 850 returned after completing their PhD training during 1990-1991. Most of them, however, were forced to seek employment in developed countries as firstly, the Ministry had not appropriately planned a career structure for these scholars, secondly, the institutions where they were to work and produce results after their return home were not simultaneously developed and thirdly, IMF loan negotiated conditions required Pakistan to impose a ban on fresh recruitment in the public sector. Lack of opportunities for employment in the private sector and lack of planning for gainful employment of these scholars resulted in huge loss to the country. Several research institutions of the Ministry of Science and Technology where these scientists were to be employed have since deteriorated mainly due to shortage of qualified manpower (S.T.K. Naim, 1992).

**Economic Implications**

There is wide agreement that human capital (people with knowledge) is a fundamental requirement for economic growth. Human capital is essential for all social and economic activities. High quality professionals are required not only for efficient governance and management of resources and institutions but also for training of new generation of scientists and engineers and for production of new technology and its commercialization. Foreign Direct Investment, increase in international trade, technology licensing and technology diffusion are all linked to the availability of a sufficient number of highly skilled scientists and engineers. Human capital is critical to building absorptive capacity for technical change.

World Bank study on Pakistan Infrastructure Capacity Assessment (2007), report No. 43186 comments that if migration of highly skilled, particularly engineers, continues, it will create a huge gap of skills that are required to implement infrastructure projects. The study reveals that in 2007, 1800 engineers emigrated overseas which is 70 percent of the number trained in 2006. The major push factor for departure of large number of engineers is identified as lowest salary offered to engineers compared to other countries in the region. The report proposes a strategy for implementing additional
training programmes for the highly skilled engineers and other professionals if Pakistan is to realize its vision of the Mid-Term 10 years Development Programme.

Pakistan trains over 4000 medical graduates annually from its institutions. Almost half of them leave the country for the United States and United Kingdom, mainly to acquire higher qualifications. Many of them never return (Adkoli, 2006). Pakistan has 0.74 doctors per 1000 of population (World Development Indicators 2007). The Aga Khan University in Karachi has received international recognition for training top class medical graduates. Aga Khan trains approximately 100 graduates each year at a cost of US$84,000 per graduate. Almost 99.9 percent students immigrate to USA after graduation. (Source: interview with Dr. Rumina Hassan, Professor at Agha Khan University

Bangladesh and Pakistan are experiencing a critical shortage of teachers, doctors, engineers and other technical staff for their expanding higher education and health systems. Shortage of skilled personnel is felt in all production activities and implementation of infrastructure related development projects. A study by the Pakistan Council for Science and Technology (2004) involving 1200 industrial units reported shortage of skilled engineers, accountants and researchers as major problems in the growth and innovation activities of industrial units. Bangladesh is also experiencing serious shortage of high quality faculty for its expanded higher education system (Kamal-ud-Din, UNESCO Science Report for South Asia 2010). Exodus of scientists, engineers and doctors from an economy should be viewed not just as lost capital but deceleration of social and economic development of source countries.

The unemployment rate for highly qualified professionals, in particular, scientists, engineers and doctors is low in Pakistan and Bangladesh as compared to the unemployment rate of other skilled, semi-skilled and low skilled workers. The average unemployment rate in individuals with tertiary education is around 22% of total unemployment rate (WDI 2007). So the main reason of migration of highly qualified professionals is not unemployment but other factors such as low salary structures, non-conducive work environment, law and order situation, uncertain career paths, political and economic instability etc.

Another huge cost of migration of highly skilled personnel to Pakistan and Bangladesh is that education, particularly professional education of doctors, engineers and scientists, is highly subsidized. The benefits of these huge subsidies go to the host countries. The societies of source countries of highly skilled migrants also pay a heavy social cost. Migration of highly skilled has a negative impact on institutional stability, economic growth and development. Strong public and private sector institutions are pillars of the State. No State can manage or govern its development programmes effectively with weak institutional infrastructure.

Gilani (1981) has reported that 83 percent of migrants from Pakistan are production workers. (these include managers, supervisors, technical and engineering staff). The loss of production workers should be calculated not only in terms of loss due to stunted industrial growth and production output as also the loss of tacit knowledge that these production workers gain through on-job training. Tacit knowledge related to manufacturing in particular is considered of high economic importance. This knowledge is acquired through experience and is accumulated over a period of time. Migration of production workers results in loss of this valuable asset to source countries and perhaps loss to the individual who may not be able to apply this knowledge in host country.
Assessment of technological capabilities of Pakistan and Bangladesh

Knowledge and innovation capabilities are considered essential for economic development. A vast amount of economic literature is devoted to studying the creation of scientific knowledge and its conversion to technological development. The linear S&T policy model which supported the generation of knowledge in the public laboratories has been replaced by innovation policy and building of the innovation systems which promote networking of all stakeholders, activities and organizations related to production and use of knowledge, in particular knowledge about technology for commercial gains. (Freeman C, 1997 and Lundvall, 2005). It is being increasingly realised that the management and organization of a country's technology infrastructure is a key determinant of its successful contribution to economic growth. Several studies by UNDP (2001), UNCTAD (2007) and Rand (2001) for assessing the relative technology capabilities of the countries are based on the use of input and output indicators. These methods have their limitations and none of these indices can truly reflect upon the level of technological development in any country as none can tell us how technological advances are embedded in a country's production systems (UNCTAD, 2007). However, they have been used extensively by the international funding and monitoring organizations to assess the relative technology competence of countries.

The most common input indicators used for determining a country’s technology capability are: (i) the human development index, (the educational attainments, literacy levels and education expenditures); (ii) the institutional infrastructure for higher education, enrolment of scientists and engineers at tertiary level, number of scientists and engineers per million of population; (iii) R&D manpower per million population; (iv) ICT infrastructure and internet access; (v) R&D expenditure from both public and private sources; (vi) technology sourcing indicators are direct capital imports, foreign direct investment and fee paid for technology licensing. The output indicators are measured in terms of (i) fee earned through licensing of technology; (ii) research publications in international journal (iii) patents filed or registered internationally and (iv) exports of high technology products. The input and output indicators of Pakistan and Bangladesh are compared with India and China.

Human Resource Development

Pakistan and Bangladesh fall behind most other developing countries in the region such as Sri Lanka, Iran, China, India and Maldives in their primary human development indicators (World Development Indicators). The education expenditures in both countries remain lower than China and India. Both countries have failed to establish infrastructure for providing education to all. The enrolment ratios at all levels and particularly in higher education remain extremely low (table 1). Since 1999 both countries have made efforts to expand their higher education system and increase enrolments. The number of universities in Bangladesh has increased from 8 in 1999 to 80 in 2006. A similar increase in the higher education sector is observed in Pakistan where the number of universities and degree awarding institutions has increased from 54 in 1999 to 133 in 2009. Despite recent expansion of the higher education in both countries, the enrolment of students at tertiary level of average 7.0 percent of age group for Bangladesh and 5 percent of age group for Pakistan remain significantly lower compared to the regional countries of India and China at 13 and 23 percent of age group enrolling in higher education respectively. In South Korea 92.6 percent of high school students enrol for higher education. (UNESCO Statistics).

Researchers in the Economy

Number of researchers per million population is also used as an indicator for assessment of innovation capacity of a country. Bangladesh (93 per million) and Pakistan (152 per million) compare
poorly with the developed countries average of 3800-4000 per million and East Asian Countries average of 3500 researchers per million population. The relative distribution of researchers in the public and private sectors also provides a reflection on the innovation capability of firms. In both Pakistan and Bangladesh almost 90 percent of researchers work in the public higher education and R&D institutions. In contrast relatively higher number (60-80%) of researchers in East Asian countries including China are employed by the private sector.

Migration of the highly skilled from Bangladesh and Pakistan has substantially reduced the number of researchers. Consequently these countries are left with significantly lower skill endowments. Several studies by UNCTAD and OECD have concluded that stock of skilled persons including scientists, doctors, engineers, researchers and high quality technical personnel is positively related to technology development, productivity increases and economic growth, the share of skilled migrant was negatively correlated with the level of development.

Expenditure on Research and Development

The second important input for technology development is R&D expenditure. R&D expenditures for Bangladesh (2004) and Pakistan (2007) are given in Table 2. In both countries the public R&D expenditure has recently increased from a mere 0.2% to 0.62% of GDP for Bangladesh and from 0.4 percent to 0.67% of GDP for Pakistan. These are still lower than the R&D expenditure of India (0.8% of GDP in 2006) and of China (1.44% of GDP) in 2007. Most developed countries spend (3-4% of much higher GDPs) as R&D expenditure. Further the R&D expenditure in Bangladesh and Pakistan is spread too thinly over several R&D institutions and universities that have emerged in past two decades. Most of the R&D effort is not goal-oriented to benefit the economy or the social sector. Linkages between universities and industries are non-existent. Private sector R&D expenditure is insignificant in both countries. Firms play a critical role in achieving technology-based development vision for any country, their activities and interactions initiate, import, modify and diffuse new technologies. (UNCTAD 2007). The private R&D expenditure in India is 20% and in China it is 70 % of total R&D expenditures. In both Bangladesh and Pakistan public policies lack appropriate vision to support firm based technology development for wealth creation, competitiveness and economic growth.

Technology Transfer

The acquisition of technology and its use as a strategic tool is an important factor for development. Technology has emerged as a driving force for domestic production, gaining competitive advantage, and exploiting opportunities for more trade in the increasingly globalised world economy. Most developing countries acquire technology through four channels, 1, Capital Imports, 2, Foreign Direct Investment (FDI),3, Technology licensing and 4, training of scientists in technologically advanced countries and engagement of Diaspora networks.

Both Bangladesh and Pakistan purchase Capital Goods technology for large infrastructure and construction projects, production technology and for scientific measurements from developed countries. Capital imports have to be combined with the training of highly skilled manpower not just for operation of machinery but for adaptation, absorption and innovation. Capital goods imports and promotion of reverse engineering practices in the local firms was a major channel of technology transfer in South Korea (Stephen Feinson, 2003). Public incentives for reverse engineering and firm level learning resulted in increasing firms capacity to absorb, adapt, innovate and produce capital goods for exports in South Korea. This was made possible through training and retraining of highly skilled manpower at firm level. China has also supported firm level technological learning to reverse
engineer imported machinery for mass production and exports. Capital Goods imports and exports by Pakistan, Bangladesh, China and India are shown in table, 3.

**Foreign Direct Investment (FDI)**

FDI is not just a source of capital and employment creation but is also a source of technology transfer and knowledge spillovers. Countries with large population and strong economic and legal institutions have negotiated FDI with technology transfer in exchange for market such as China and India. The green field FDI is a form of FDI where a company starts a new venture by constructing new operational facilities and creates new employment opportunities. The FDI inflows including green field projects for Pakistan and Bangladesh are shown in table 3. The attractiveness of countries for FDI inflows depend on several factors including cheap natural resources, security, infrastructure, economic and political stability and incentives a country offers for foreign investment. The most important factor however, is the presence of skilled labour force and centres of excellence.

The migration of highly skilled engineers, managers and complementary manpower such as production workers is most likely to have an adverse effect on the FDI inflows and technology development initiatives of countries such as Pakistan and Bangladesh.

**Royalty and License Fee Payment and Receipts**

The fee paid for purchase of technology through licensing is an input indicator and fee earned by the sale of technology through licensing is an output indicator. The amount spent for licensing of technology by both countries is given in figure 7. The licensing of foreign technology for manufacturing or services by local firms needs to be combined with incentives for learning and innovation activities at firms which should result in licensing fee or royalties earned from technology exports. In 2007 Pakistan earned US$37 million and Bangladesh only US$0.04 million as licensing fees for sale of their technology whereas India earned US$111.6 million and China US$204.5 million in the same year.

This shows that in both Pakistan and Bangladesh, public incentives have not encouraged design and engineering capabilities in the private firms. There is shortage of high quality engineers in the country. Migration of engineers has hampered the process of technological learning, product or process improvement and competitiveness of both countries.

**Research Papers in International Journals**

Research papers contributed from scientists in international journals is an output indicator frequently used to assess knowledge generation and innovation capability of a country. Trends of research publication contributed by the institutions of Bangladesh, Pakistan, India and China are given in figure 8. The lower number of research articles contributed by Bangladesh and Pakistan indicate the presence of few productive scientists and engineers, lower R&D budgets and inadequate infrastructure for R&D. Worsening the situation further is the migration of scientists and engineers which further lowers the output of the country’s institutions and their contribution to knowledge generation. The recent increase in the output of scientific research from Asia is attributed to a six fold increase in the number of scientific research articles from China from 9000 S&E articles published in 1991 to nearly 57000 in 2008.

**Patent Application Filed and Patents Registered**

Patent applications filed or registered in national and international patents offices is a measure of potential commercialization of created knowledge and innovation activity. Figure 9 shows that most patent applications filed are from non-residents, i.e. subsidiaries of foreign companies operating in the
country. Patents applications filed from national institutions of Bangladesh and Pakistan are insignificant compared with China and India.

The increase in research activities in the form of published research articles or patents results in building absorptive capacity of public and private sectors which is essential for import, adaptation, absorption, innovation and commercialization of technology.

**Information Infrastructure**

Information and communication technologies as enabling technologies provide a means for bridging the knowledge gap between developed and developing countries. High quality ICT infrastructure and its wider access is considered essential for countries wishing to transition their economies from resource based to knowledge intensive economies. IT technologies provide access to local and global knowledge networks for e-education and e-commerce. Figure 10, provides information on relative internet coverage in four South Asian countries. Bangladesh has the lowest ICT coverage whereas Pakistan has shown some improvement since 2003. Both countries however are far behind China in their indicators of access to internet technology.

**Innovation Capacity and Competitiveness**

The World Bank Knowledge Economy Index (KEI) has benchmarked countries on the basis of four pillars of knowledge economy: (i) economic incentives and institutional regime; (ii) education and human resources; (iii) the innovation system and (iv) ICT infrastructure. Bangladesh and Pakistan are placed in 138 and 118 positions respectively among 146 countries. Pakistan has shown some improvement in its KEI ranking. Its KEI position at 127 in 1995 has changed to 118 in 2009. The only country in the region which has shown considerable improvement in KEI Index is China with a change in position from 100 in 1995 to 81 in 2009. (table 4).

The global competitiveness report has identified the following five stages in the economic development of countries: (i) factor driven; (ii) transition; (iii) efficiency; (iv) transition; (v) innovation. This classification is based on 12 pillars for which a number of indicators have been developed. These include institutions; infrastructure; macroeconomic stability; health and primary education; higher education and training; goods market efficiency; labour market efficiency; financial market sophistication; technology readiness; market size; business sophistication and innovation. Within this framework economies of all countries in South Asia including India are classified as resource based. (The Global Competitiveness Report 2009-2010).

The above indicators show that both Pakistan and Bangladesh have underdeveloped innovation systems and weak technological capabilities. The critical requirement for building technology capacity is the number and availability of highly skilled people. Continuous migration of the skilled labour has reduced the number of scientists, engineers and other professionals required for introducing technical change in major sectors of the economy. These sectors need to modernise with fresh input of knowledge and of technology and by hiring skilled scientists and engineers for adaptation, absorption and innovation.

**Conclusions**

The global labour market for the highly skilled has expanded and will continue to expand as demand for highly skilled in the developed world will increase further due to their demographic transition and the increasing demand of knowledge workers by their economies. Pakistan and Bangladesh train relatively fewer doctors, engineers and scientists compared to developed economies. A very small percentage of the age group are enrolled in institutions of higher learning, average 5.0
percent compared to average 35-50 percent enrolled in tertiary education in developed countries. In addition, there are only a few institutions providing quality education. Migration of the highly skilled has created critical shortage of teachers, doctors, engineers and production workers badly affecting the quality of services needed for building social and economic infrastructure and for technology development.

There is wide consensus that technological capabilities are essential for higher economic growth and improvements in living standards. The potential of building innovation and technology capability exists in both countries. This potential however, is largely dependent on the political will of these countries to devote a higher percentage of their GDPs for education in general and for higher education in particular; to address issues of access, quality and relevance; invest in high quality research infrastructure and create conditions for the highly skilled to work in the country and to offer incentives for diaspora to return. In both Pakistan and Bangladesh the social institutions such as universities as also those related to economic growth, such as the industrial clusters in textiles, leather, pharmaceuticals and agriculture sector and also those operating in other services sectors are operating at low level of knowledge and technology. New energy in the form of advanced human skills and technology is needed to modernize these sectors.

Bangladesh and Pakistan, with low skill endowment and high levels of skilled migrants are at risk of experiencing considerable delays and heavy costs in meeting growing demands of their underdeveloped economies. Both countries have been left behind in the race of technological catch-up and industrial growth. The development gap between Pakistan, Bangladesh and the developed countries will increase further if these two countries further delayed to implement policies and programmes related to structural reforms of their economies to promote entrepreneurship, and to root out corruption; extend education facilities to all to increase skill base; train sufficient number of high quality scientists, engineers, and doctors, to carry out institutional reforms for (better governance and management, transparency and accountability) and improve incentives (higher salaries, career paths, merit based promotions) provisioning of world class infrastructure for research and availability of research funding to retain their highly skilled personnel in the country. Both countries need to initiate programmes to attract some of their highly skilled diaspora back to the country for transfer of knowledge to the universities and for consultation on reforms of their key institutions, technology and knowledge transfer to public institution, the private enterprises and for investment and entrepreneurship. The examples of Taiwan, South Korea, India and China demonstrate that diaspora networks can serve as Brain Reserve for stimulating high technology businesses at home.

References


NOTES

21. The terms highly skilled and highly qualified have been used interchangeably in this paper. Both refer to persons holding a graduate degree or above in Medical Sciences or Engineering, or holding a Master’s degree or above in any other discipline.

22. Under-skilled and semi-skilled labour refers to the workers who do not have an educational degree but have skills to provide services to the economy such as tailors, mechanics, construction workers etc.
Figure 1: Trends of Overseas Employment (1976-2007), Bangladesh

Figure 2: Preferred destination for Overseas Employment (Bangladesh) – 1976-2007

* K.S.A = Kingdom of Saudi Arabia
** U.A.E = United Arab Emirates

Figure 3: Overseas Employment of Skilled and Semi-Skilled Manpower (2001-2008), Pakistan

Source: Bureau of Emigration and Overseas Employment, Pakistan

Figure 4: Highly Skilled Migrants from Pakistan (2001-2008)

Source: Bureau of Emigration and Overseas Employment, Pakistan
Figure 5: Preferred destination for Overseas Employment (Pakistan) – 1976-2007

Source: Bureau of Emigration and Overseas Employment, Pakistan
Figure 6: Year Wise Remittances (1998-2008) – Bangladesh and Pakistan


Figure 7: Royalties and License Fees, Payments and Receipts - Million US$ (2007)

Figure 8: Scientific articles published in International Journals and Proceedings (2000-2009)

Source: ISI Web of Knowledge
Figure 9: Patent Applications (Resident & Non-resident & USPTO by country of origin, 2008)

Source: U.S. Patent and Trademark office; World Intellectual Property Organization; (data refers to most recent year available)
Figure 10: Internet users per 100 Inhabitants (2003 and 2009)

Source: ITU World Telecommunication/ICT Indicators Database
Table 1: Education Indicators (Bangladesh, India, China and Pakistan)

<table>
<thead>
<tr>
<th>Name of Country</th>
<th>Tertiary Gross Enrolments ratio (% of relevant age group) 2007</th>
<th>Adult Literacy Rate (% of age 15 and above) 2007</th>
<th>Public expenditure on education (% of GDP) 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>7</td>
<td>53.0**</td>
<td>2.4</td>
</tr>
<tr>
<td>India</td>
<td>13</td>
<td>66.0</td>
<td>5.1</td>
</tr>
<tr>
<td>China</td>
<td>23</td>
<td>93.7**</td>
<td>1.9 (1999)</td>
</tr>
<tr>
<td>Pakistan</td>
<td>5</td>
<td>54.89</td>
<td>2.9</td>
</tr>
</tbody>
</table>

** UIS estimation

Source: UNESCO Institute of Statistics; (ii) UNESCO 2009, Global Digest 2009

Table 2: Research Indicators – (Bangladesh, India, China and Pakistan)

<table>
<thead>
<tr>
<th>Name of Country</th>
<th>Researchers in R&amp;D (per million population 2007) (in FTE)</th>
<th>Science and Engineering Enrolment Ratio (%) 2007</th>
<th>GERD / GDP ratio (%) 2007</th>
<th>Private share in R&amp;D (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>46 -10, HC</td>
<td>13.81</td>
<td>0.62 (2000-04)</td>
<td>n/a</td>
</tr>
<tr>
<td>India</td>
<td>137 e</td>
<td>20.26</td>
<td>0.80 e</td>
<td>20</td>
</tr>
<tr>
<td>China</td>
<td>1071 (bx)</td>
<td>40**</td>
<td>1.44</td>
<td>70</td>
</tr>
<tr>
<td>Pakistan</td>
<td>152 +</td>
<td>10.21**</td>
<td>0.67*</td>
<td>10***</td>
</tr>
</tbody>
</table>

HC = Head count instead of Full-time equivalent (FTE); e = estimation;
* = Civil R&D only, for civil and military R&D combined, the GERD/GDP ratio for Pakistan is 0.9%
(bx) Do correspond exactly to frascati manual recommendation
** = S&E degree awarded
*** = approx.

Table 3: Capital Goods Imports (2003-07) and Exports, Foreign Direct Investment and Number of Greenfield FDI projects by Destination (2008) - (Bangladesh, China, India and Pakistan)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>2719.75</td>
<td>1659.02</td>
<td>1086</td>
<td>11</td>
</tr>
<tr>
<td>India</td>
<td>31898.21</td>
<td>205.90</td>
<td>41554</td>
<td>958</td>
</tr>
<tr>
<td>China</td>
<td>327187.92</td>
<td>150000.00.00</td>
<td>108312</td>
<td>1483</td>
</tr>
<tr>
<td>Pakistan</td>
<td>5919.57</td>
<td>2239.09</td>
<td>5438</td>
<td>25</td>
</tr>
</tbody>
</table>


Table 4: Knowledge Economy Index (KEI for 1995 and 2009) and Global Competitiveness Index (2005 and 2009-10)

<table>
<thead>
<tr>
<th>Countries</th>
<th>KEI Index (146 countries)</th>
<th>WEF Global Competitiveness Index (133 countries)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1995</td>
<td>2009</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>138</td>
<td>138</td>
</tr>
<tr>
<td>China</td>
<td>100</td>
<td>81</td>
</tr>
<tr>
<td>India</td>
<td>108</td>
<td>109</td>
</tr>
<tr>
<td>Pakistan</td>
<td>127</td>
<td>118</td>
</tr>
</tbody>
</table>

Institutional Prerequisites of Innovative, Technological and Structural Dynamics (Russian case).

Dr. Rustem Nureev
State University - Higher School of Economics Moscow, Chief of the Department of Economic Analysis of Markets and Organizations, Professor;

1. Russian economic specialization: light and shadows

The economic crisis has uncovered three negative Russian tendencies that created institutional obstacles for market economy growth during the last decade: deepening of raw materials specialization, wear and tear of the equipment, gap in scientific and technical progress, and strengthening of the government. To stop these negative tendencies and overcome economic crisis it is necessary to reform developed institutes.

<table>
<thead>
<tr>
<th>Types of industrial and agricultural production</th>
<th>Russian position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas, Oil extracted</td>
<td>1</td>
</tr>
<tr>
<td>Potato</td>
<td>2</td>
</tr>
<tr>
<td>Wood, Bricks, Meat and poultry, Cast iron, Sugar beet</td>
<td>3</td>
</tr>
<tr>
<td>Electricity, Steel, Finished steel of ferrous materials, Mineral fertilizers, Cotton, Grain crops</td>
<td>4</td>
</tr>
<tr>
<td>Iron ore, Cement, Milk</td>
<td>5</td>
</tr>
<tr>
<td>Coal, Saw timber, Meat and poultry</td>
<td>6</td>
</tr>
<tr>
<td>Cellulose, Butter</td>
<td>7</td>
</tr>
<tr>
<td>Fishing</td>
<td>8</td>
</tr>
<tr>
<td>Woollen fabric, Footwear</td>
<td>10</td>
</tr>
<tr>
<td>Motor cars (assembling included), Paper and board converting</td>
<td>11</td>
</tr>
</tbody>
</table>


Russia ranks first in the world in natural gas production, oil extraction, holds the second place for potatoes and the third place - for wood, bricks, meat and poultry, cast iron and sugar beet (see Table 1).

In 2007 Russia accounted for 2.2% of the world population. However, for some types of commercial products its contribution to world production is significantly higher than its share in world population: 27.2% of world natural gas production, 12.6% of
global oil production, 6% of global iron ore production and 5% of world coal production (see Table. 2).

Table 2. Russia in the world production (%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average population size, percent</td>
<td>2.6</td>
<td>2.4</td>
<td>2.2*</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil (including gas condensate), ton</td>
<td>9.9</td>
<td>9.7</td>
<td>12.6</td>
</tr>
<tr>
<td>Natural gas, m3</td>
<td>27</td>
<td>23</td>
<td>27.2</td>
</tr>
<tr>
<td>Coal, ton</td>
<td>5.7</td>
<td>5.7</td>
<td>5</td>
</tr>
<tr>
<td>Iron ore (commodity), ton</td>
<td>8.5</td>
<td>9.1</td>
<td>6</td>
</tr>
<tr>
<td>Industrial goods production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>6.5</td>
<td>5.7</td>
<td>5.3</td>
</tr>
<tr>
<td>Cast iron, mln. ton</td>
<td>7.6</td>
<td>7.7</td>
<td>7</td>
</tr>
<tr>
<td>Steel, mln. Ton</td>
<td>6.9</td>
<td>7</td>
<td>6.2</td>
</tr>
<tr>
<td>Cars (including assembly)</td>
<td>2.1</td>
<td>2.3</td>
<td>2.4</td>
</tr>
<tr>
<td>Fertilizer, mln. ton</td>
<td>7.1</td>
<td>8.5</td>
<td>9.3</td>
</tr>
<tr>
<td>Wood (removal), mln. m3</td>
<td>3.6</td>
<td>2.8</td>
<td>3.3</td>
</tr>
<tr>
<td>Timber, mln. m3</td>
<td>6.5</td>
<td>5.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Paper and cardboard, mln. ton</td>
<td>1.5</td>
<td>1.6</td>
<td>2</td>
</tr>
<tr>
<td>Cement, mln. Ton</td>
<td>2.6</td>
<td>2</td>
<td>2.1</td>
</tr>
<tr>
<td>Cotton fabric, m2</td>
<td>1.9</td>
<td>2.7</td>
<td>3.5</td>
</tr>
<tr>
<td>Woolen fabric, m2</td>
<td>2.8</td>
<td>2.4</td>
<td>2</td>
</tr>
<tr>
<td>Footwear, pairs</td>
<td>1.3</td>
<td>0.9</td>
<td>…</td>
</tr>
<tr>
<td>Sugar (made of domestic materials), mln. ton</td>
<td>1.8</td>
<td>1.3</td>
<td>1.4</td>
</tr>
<tr>
<td>Fishing and other seafood, mln. ton</td>
<td>4.2</td>
<td>4</td>
<td>3.2</td>
</tr>
</tbody>
</table>

* - 2005

Source: Calculated on the database of Mineral Commodity Summaries and Rosstat.

Russian position is also a visible one in the production of fertilizers (9.3% of world production in 2007), iron (7%), steel (6.2%), electricity (5.3%), lumber (5.3%) and cotton fabrics (3.5%, see: Table 2). Year after year, the share of Russia in the global car assembling is increasing. In 2007 Russia accounted for 2.4% of world production.

Table 3. Export commodity structure in Russian Federation, 1995-2008 (%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total export</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>including:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foodstuffs and agricultural materials (except textile)</td>
<td>1.8</td>
<td>1.6</td>
<td>1.9</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Russian success during the last few years is connected with changes of its role in the world economy. Russia is becoming a raw-materials country, which is reflected in the structure of its exports. If in 1995 mineral products accounted for 42.5% of all Russian exports, then in 2008 their share grew to 69.6%, while the share of machinery and equipment fell almost 2 times - from 10.2% up to 4.9% (See Table 3).

Table 4. Import commodity structure in Russian Federation, 1995-2008 (%)  

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Import - total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>including:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foodstuffs and agricultural materials (except textile)</td>
<td>28.1</td>
<td>21.8</td>
<td>17.7</td>
<td>13.2</td>
</tr>
<tr>
<td>Mineral products</td>
<td>6.4</td>
<td>6.3</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>output of chemical industry, rubber</td>
<td>10.9</td>
<td>18</td>
<td>16.5</td>
<td>13.1</td>
</tr>
<tr>
<td>tanning materials, furs and products which are made of furs</td>
<td>0.3</td>
<td>0.4</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>wood and pulp and paper products</td>
<td>2.4</td>
<td>3.8</td>
<td>3.3</td>
<td>2.4</td>
</tr>
<tr>
<td>textile, textile products and wear foot</td>
<td>5.7</td>
<td>5.9</td>
<td>3.7</td>
<td>4.4</td>
</tr>
<tr>
<td>metals, precious stones and products which are made of it</td>
<td>8.5</td>
<td>8.3</td>
<td>7.7</td>
<td>7.3</td>
</tr>
<tr>
<td>machines, equipment and means of transport</td>
<td>33.6</td>
<td>31.4</td>
<td>44</td>
<td>52.7</td>
</tr>
<tr>
<td>Other goods</td>
<td>4.1</td>
<td>4.1</td>
<td>3.7</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Source: The Federal Customs Service of Russia

On the contrary, in the recent years imports of machinery, equipment and vehicles greatly increased (from 33.6% in 1995 to 52.7% in 2008) and products of chemical industry and rubber rose from 10.9% in 1995 to 13.1% in 2008 (See Table 4).
The problem is worsened by the fact that Russian natural resources (including both oil and gas) will soon be exhausted. Russia's oil reserves will be sufficient only until 2030. The level of reproduction of oil and condensate continues to lag behind the volume of their production. In 2002 oil reserves amounted to 254 million tons (production - 380 million tons), in 2003 - 240 million tons (production - 421 million tons), in 2004 - 440 million tons of oil were produced.

CIS countries have enough oil for 30 years, gas - for 70 years and coal - for 460 years [counted if there will be no change in consumption level (see Figure 1)].

Most OECD countries have enough coal for 170 years, and the rest of Europe and Asia - enough gas for 100 years, oil for 60 years and coal – for 70 years. In terms of natural energy resources exploitability the role of other resources (especially human capital) has increased.

This analysis allows to draw at least two conclusions. First, it is necessary to use financial resources, derived from the sale of oil and gas, to modernize Russian economy and to overcome its single-crop specialization. Second, it must be done so in the nearest future, as it becomes difficult to maintain oil and gas production even at the same level.

2. The level of Russian innovative development.

The effectiveness of investing in science influences the way innovations are introduced. Innovation possibilities index consists of five interrelated indexes:

- Scientists and engineers index,
• Innovation policy index,
• Cluster environment index,
• Connection with universities index
• Companies’ activities and strategies index.

Relative position of Russia in comparison with other countries is shown in the Table 5.

Table 5. Innovation possibilities index: comparative position of Russia in 2004

<table>
<thead>
<tr>
<th>Place</th>
<th>Scientists and engineers index</th>
<th>Innovation policy index</th>
<th>Cluster environment index</th>
<th>Connection with universities index</th>
<th>Companies activities and strategies index</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Russia (9)</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>41</td>
<td>Italy</td>
<td>Greece</td>
<td>Morocco</td>
<td>Indonesia</td>
<td>Portugal</td>
</tr>
<tr>
<td>42</td>
<td>Latvia</td>
<td>Czech Republic</td>
<td>Russia</td>
<td>Portugal</td>
<td>Lithuania</td>
</tr>
<tr>
<td>43</td>
<td>Romania</td>
<td>Lithuania</td>
<td>Nigeria</td>
<td>Egypt</td>
<td>Mauritius</td>
</tr>
<tr>
<td>44</td>
<td>Argentina</td>
<td>Slovakia</td>
<td>Cyprus</td>
<td>Uganda</td>
<td>Egypt</td>
</tr>
<tr>
<td>45</td>
<td>Mozambique</td>
<td>Botswana</td>
<td>Bahrain</td>
<td>Turkey</td>
<td>India</td>
</tr>
<tr>
<td>46</td>
<td>China</td>
<td>Namibia</td>
<td>Turkey</td>
<td>Russia</td>
<td>Poland</td>
</tr>
<tr>
<td>47</td>
<td>Costa Rica</td>
<td>Bahrain</td>
<td>Estonia</td>
<td>Hungary</td>
<td>Jordan</td>
</tr>
<tr>
<td>48</td>
<td>Egypt</td>
<td>Italy</td>
<td>Ukrain</td>
<td>Jordan</td>
<td>Hungary</td>
</tr>
<tr>
<td>49</td>
<td>Trinidad and Tobago</td>
<td>Malta</td>
<td>Mexico</td>
<td>Jamaica</td>
<td>Mexico</td>
</tr>
<tr>
<td>50</td>
<td>Croatia</td>
<td>Jordan</td>
<td>Slovenia</td>
<td>Bahrain</td>
<td>Tunisia</td>
</tr>
<tr>
<td>51</td>
<td>Macedonia</td>
<td>Chili</td>
<td>Lithuania</td>
<td>Costa Rica</td>
<td>Estonia</td>
</tr>
<tr>
<td>52</td>
<td>Indonesia</td>
<td>Croatia</td>
<td>Philippines</td>
<td>Trinidad and Tobago</td>
<td>Pakistan</td>
</tr>
<tr>
<td>53</td>
<td>Mauritius</td>
<td>Serbia</td>
<td>Kenya</td>
<td>Panama</td>
<td>Pakistan</td>
</tr>
<tr>
<td>54</td>
<td>Tunisia</td>
<td>Tanzania</td>
<td>Panama</td>
<td>Namibia</td>
<td>Botswana</td>
</tr>
<tr>
<td>55</td>
<td>Morocco</td>
<td>Uganda</td>
<td>Greece</td>
<td>Madagascar</td>
<td>Morocco</td>
</tr>
<tr>
<td>56</td>
<td>Brazil</td>
<td>Egypt</td>
<td>Mauritius</td>
<td>Mali</td>
<td>Thailand</td>
</tr>
<tr>
<td>57</td>
<td>Turkey</td>
<td>Gambia</td>
<td>Czech Republic</td>
<td>Mauritius</td>
<td>Namibia</td>
</tr>
<tr>
<td>58</td>
<td>Uruguay</td>
<td>Trinidad and Tobago</td>
<td>Colombia</td>
<td>Vietnam</td>
<td>Trinidad and Tobago</td>
</tr>
<tr>
<td>59</td>
<td>Malaysia</td>
<td>Trinidad and Tobago</td>
<td>Namibia</td>
<td>Botswana</td>
<td>Salvador</td>
</tr>
<tr>
<td>60</td>
<td>Vietnam</td>
<td>Mali</td>
<td>Tanzania</td>
<td>China</td>
<td>Russia (63)</td>
</tr>
</tbody>
</table>

In terms of innovative capacities Russia took a total 35th place. However, it is characterized by a strong variation between the indicators that make up the index (see Table 6). The Scientists and engineers index value for Russia is the 9th highest in the world, the Cluster environment index – 41st, the Connection with universities index - 45th, the Innovation policy index - 58th, and the Companies activities and strategies index - only 63rd. Such a large variation between different aspects of innovative capabilities significantly reduces the overall efficiency. Russian patenting rate is smaller than in China and India (see Fig. 2).

Russian system of innovation is strong at its input and relatively weak at the output. Russia traditionally spends a noticeable share of GDP on research and development. However private business invests in science very little. Businessmen still enjoy the possibility of extensive growth, growth based on expanding the market more than its intensification. It is therefore not surprising that the majority of Russian inventions are patented in other countries, including the US, which use Russian scientific resources actively.

According to UNESCO, by number of employees engaged in research and development Russia takes 4th place after the United States, China and Japan. However, what is more important is not the number of researchers, but their effectiveness.

In recent years the Russian government has introduced several initiatives under its innovation policy. These include establishing special areas to promote science and
technology. These measures will affect companies located within the territory of those members of the Russian Federation, where these special zones are situated.

The major problem of the Russian economy is its low performance level. Overcoming development gap in comparison with developed countries will become possible only with the help of innovations. This means that process of generating and using Schumpeterian-type innovations should become the key factor of economic development. It is necessary to note that innovative activity of businessmen can be present in various forms. Depending on existing game rules business activity can get not only productive (J. A. Schumpeter’s creative destruction), but also unproductive (rent seeking) orientation.

3. Long-term forecasts of scientific and technological development of the Russian federation

3.1. Advantages and disadvantages of «The Concept of Long-term Socio-Economic Development of Russian Federation»

In March 2008 the Russian Ministry of Economic Development and Trade prepared «The concept of long-term socio-economic development of the Russian Federation», which established the program for long-term development of the country until 2020. It attempts to answer the challenges of the coming decade. These include the strengthening of global competition, a new wave of technological change and the increasing role of human capital as a real alternative to the exhaustion of sources of export and commodity development.

As history shows there is a compression of historical time. It does not mean, however, that all countries simultaneously will pass to a postindustrial society. Calculations show that it will occur far not to all countries. Rupture between the OECD countries and the countries of Tropical Africa even will increase (see Fig. 3).
These challenges are exacerbated by a growing number of unresolved social and institutional problems: high levels of social inequality and regional differentiation, the persistence of barriers to doing business, a weak interrelation of education, science and business, lack of competition in a number of markets and the low level of development of social capital. Under these conditions, as A. Gerschenkron wrote, the government becomes the leading factor of economic modernization, and it is its representatives that try to shape the concept of long-term socio-economic development of the country.

The strategic goal of this concept is to make Russia a leading country in the world in the 21st century. By 2020 according to the authors of the concept, Russia will be one of five top countries by GDP. Experts formally described three main development scenarios – inertial (energy and raw materials oriented), innovative and socially-oriented development. But the concept is actually focused on the last one.

All three variants do not assume fast growth of oil and gas production. However in case the innovative scenario will be implemented, slightly higher growth rates are assumed (see Figure 4).

Targets set are very ambitious. In order to achieve these goals, it is necessary to:

- accelerate development of Russian human potential,
- create a highly competitive institutional environment that encourages entrepreneurial activity and attracts foreign investments,
- structurally diversify the economy through innovative technology development,
- strengthen and expand the global benefits of Russia in the traditional sectors (energy, transport, agriculture and processing of natural resources),
- increase the effective participation of Russia in the global division of labor and implement new spatial development model of the Russian economy.
Three periods of innovative development of economy are set: 1) from 2008 to 2012, 2) from 2013 to 2017, 3) from 2018 to 2020. The prognosis for development of macroeconomic indicators of Russia's economy in selected years is shown in Table 6.

Table 6. Target macroeconomic indexes of Russian economy development till 2020 year

(2007=100)

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2017</th>
<th>2020</th>
</tr>
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<tbody>
<tr>
<td>GDP growth</td>
<td>135-136</td>
<td>137-139</td>
<td>119-122</td>
</tr>
<tr>
<td>Labour productivity growth</td>
<td>137-139</td>
<td>142-144</td>
<td>121-124</td>
</tr>
<tr>
<td>Decline in power-consuming of GDP</td>
<td>83-84</td>
<td>80-82</td>
<td>88-91</td>
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</table>

It is expected that primary source of GDP growth will be a faster productivity growth and tremendous growth of investments. The last one significantly outscores the growth of productivity and GDP, which should lead to an increase in capital intensity of production and a fall of a yield on capital investment. It is assumed that R&D expenditures will reach 1.8% of GDP in 2012, 3.3% in 2017 and 4% in 2020. Growth in real per capita income is planned at a faster pace than GDP growth. Education expenditures made by the end of the planned period will constitute 5.5-6% of GDP, while public health expenditures will increase from 3.7% in 2007 to 6.7-7% in 2020.

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</tr>
</thead>
<tbody>
<tr>
<td>Increase in real disposable income</td>
<td>148-150</td>
<td>137-140</td>
<td>120-123</td>
<td>167-170</td>
<td>165-168</td>
<td>130-133</td>
<td>5-5,2</td>
<td>5,3-5,7</td>
<td>5,5-6,0</td>
<td>5-5,3</td>
<td>5,8-6</td>
<td>6,7-7</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Investments</td>
<td>167-170</td>
<td>165-168</td>
<td>130-133</td>
<td>167-170</td>
<td>165-168</td>
<td>130-133</td>
<td>5-5,2</td>
<td>5,3-5,7</td>
<td>5,5-6,0</td>
<td>5-5,3</td>
<td>5,8-6</td>
<td>6,7-7</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>R &amp; D expenditures, % GDP</td>
<td>1,8</td>
<td>3,3</td>
<td>4,0</td>
<td>1,8</td>
<td>3,3</td>
<td>4,0</td>
<td>1,8</td>
<td>3,3</td>
<td>4,0</td>
<td>1,8</td>
<td>3,3</td>
<td>4,0</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education expenditures at the end of period, % GDP</td>
<td>5-5,2</td>
<td>5,3-5,7</td>
<td>5,5-6,0</td>
<td>5-5,3</td>
<td>5,8-6</td>
<td>6,7-7</td>
<td>5-5,2</td>
<td>5,3-5,7</td>
<td>5,5-6,0</td>
<td>5-5,3</td>
<td>5,8-6</td>
<td>6,7-7</td>
<td></td>
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<tr>
<td>Health services expenditures, at the end of period, % GDP</td>
<td>5-5,2</td>
<td>5,8-6</td>
<td>6,7-7</td>
<td>5-5,2</td>
<td>5,8-6</td>
<td>6,7-7</td>
<td>5-5,2</td>
<td>5,8-6</td>
<td>6,7-7</td>
<td>5-5,2</td>
<td>5,8-6</td>
<td>6,7-7</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Figure 5. Dynamic of direct foreign investments (billion, $)

Analyzing the macroeconomic trends, the authors assume that rapid growth of imports, on the one hand, and lower prices of oil and metals, on the other hand, may lead
to a negative balance of payments already by 2010. Despite the alleged export of engineering products, a negative trade balance will remain until the 2018-2020 years and reach 90-110 billion U.S. dollars (or 2% of GDP). The authors naively believe that the current account deficit will be offset by a sharp expansion of foreign capital inflows, which was at a level no lower than 3-3.5% of GDP (see Fig. 5). All these will provide a sharp decline in inflation to 3% per year by 2020.

It will allow to increase export of highly technology products from 0.7 bln. dollars in 2005-2008 to 4.3 bln. dollars in 2017-2020. However if the intensive plan for development is not realized, level of export of highly technology products will be at 5-10 time less of planned level (see Fig. 6).

The development of the national innovation system will enhance the Russian position in the international arena and will contribute to the development of its comparative advantage in the competitive field of nuclear technologies, aircraft, shipbuilding, space-based services and devices, software, educational and intellectual services, as well as services in the field of tourism.

![Figure 6. Potential of Russian advanced technology products export (mldr. $)](image)

Source: Realisation of competitive advantages is the base of economic growth in long-term outlook, M. Center for Macroeconomic Analysis and short-term forecasting, 2007, slide 17

Creation of such a strong plan for socio-economic development of Russia represents a significant step forward compared with 1990-s when everything was given at the mercy of unruly market forces. For the first time in the entire post-Soviet era
The government is trying to take the strategic initiative in its own hands. Certainly it is very good that the plan has a strong social dimension. In any case, public policy priorities are more or less clearly defined. The advantage is also that not only one but three scenarios are dealt with, and though the preference is given to an innovation-based one the difference between the three scenarios is not that big\(^2\).

The point is that for all three scenarios a rise in efficiency of the economy is implied. The biggest difference between the three scenarios is a more rapid growth of investment under innovative scenario, which, as it has already been mentioned, will inevitably lead to a fall of a yield on capital investment. As GDP growth has lagged behind investment growth, the authors of the Concept focus on extensive accruing of the capital stock.

The emerging imbalance between exports and imports, from the authors of the Concept point of view, will be offset by increasing foreign capital inflows, which also is highly questionable, as well as a sharp (in seven times) increase of exports of machinery. Authors of the Concept suggest that the increase in expenditure on R & D will yield a return only at the end of the planned period. This also indicates reliance on extensive growth.

However, the main drawback is a mechanism to ensure this growth. Setting goals and identification of specific parameters of development is an important but insufficient condition for economic development. Institutional problem of ensuring that growth doesn’t withstand even the most sympathetic touch of criticism. Although, from time to time, calls for greater investment by the private sector are issued, but a mechanism to stimulate development in this area is not developed. It should be remembered that the role of the state (which is the main driver of technological progress, according to the Concept) as a result of the privatization process is extremely modest. Meanwhile, a sharp increase in spending on social services will raise a question of supplying the budget with necessary funds. This can be achieved either by raising taxes, or by expanding the public sector. However, neither way, fortunately, is not anticipated.

### 3.2. RAND Corporation forecast (USA)

Scientists of RAND Corporation (USA) published in 2006 a study on the global technological revolution of 2020, on the material in 29 countries and 16 technologies. They divided all countries into 4 groups, marking their respective colors on the map: the most advanced countries are marked in blue, following them - green, developing science - in yellow and those that lag behind in science - red (see Figure. 7).

Typical technologies (TT) market the numbers:

1. **Cheap solar energy**: Solar energy systems inexpensive enough to be widely available to developing and undeveloped countries, as well as economically disadvantaged populations.
2. **Rural wireless communications**: Widely available telephone and Internet connectivity without a wired network infrastructure.

3. **Communication devices for ubiquitous information access:** Communication and storage devices—both wired and wireless—that provide agile access to information sources anywhere, anytime. Operating seamlessly across communication and data storage protocols, these devices will have growing capabilities to store not only text but also meta-text with layered contextual information, images, voice, music, video, and movies.

4. **Genetically modified (GM) crops:** Genetically engineered foods with improved nutritional value (e.g., through added vitamins and micronutrients), increased production (e.g., by tailoring crops to local conditions), and reduced pesticide use (e.g., by increasing resistance to pests).

5. **Rapid bioassays:** Tests that can be performed quickly, and sometimes simultaneously, to verify the presence or absence of specific biological substances.

6. **Filters and catalysts:** Techniques and devices to effectively and reliably filter, purify, and decontaminate water locally using unskilled labor.

7. **Targeted drug delivery:** Drug therapies that preferentially attack specific tumors or pathogens without harming healthy tissues and cells.

8. **Cheap autonomous housing:** Self-sufficient and affordable housing that provides shelter adaptable to local conditions, as well as energy for heating, cooling, and cooking.

9. **Green manufacturing:** Redesigned manufacturing processes that either eliminate or greatly reduce waste streams and the need to use toxic materials.
NOTE: Countries were selected as representative of groups of similar nations in a single geographical area. Countries are color coded by their S&T capacity: scientifically advanced (blue), scientifically proficient (green), scientifically developing (yellow), and scientifically lagging (red). Technology application (TA) numbers are as follows: (1) cheap solar energy, (2) rural wireless communications, (3) ubiquitous information access, (4) GM crops, (5) rapid bioassays, (6) filters and catalysts, (7) targeted drug delivery, (8) cheap autonomous housing, (9) green manufacturing, (10) ubiquitous RFID tagging, (11) hybrid vehicles, (12) pervasive sensors, (13) tissue engineering, (14) improved diagnostic and surgical methods, (15) wearable computers, (16) quantum cryptography.

**Figure 7. Potential of separate countries on making 16 technologies.**


10. **Ubiquitous radio frequency identification (RFID) tagging of commercial products and individuals:** Widespread use of RFID tags to track retail products from manufacture through sale and beyond, as well as individuals and their movements.
11. *Hybrid vehicles:* Automobiles available to the mass market with power systems that combine internal combustion and other power sources while recovering energy during braking.

12. *Pervasive sensors:* Presence of sensors in most public areas and networks of sensor data to accomplish real-time surveillance.


14. *Improved diagnostic and surgical methods:* Technologies that improve the precision of diagnoses and greatly increase the accuracy and efficacy of surgical procedures while reducing invasiveness and recovery time.

15. *Wearable computers:* Computational devices embedded in clothing or in other wearable items, such as handbags, purses, or jewelry.

16. *Quantum cryptography:* Quantum mechanical methods that encode information for secure transfer.$^{30}$

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Figure 8 Potential of separate countries on introduction 16 technologies.


RAND Corporation provides an assessment of the capacity of individual countries on the introduction of advanced technologies (See Fig. 8). The blue quadrant indicates a high level of scientific and technological capabilities, as well as the many points of the growth of relevant technologies in the presence of relatively high barriers to growth. Green quadrant indicates a high level of scientific and technological capacity building and a number of growth points, which limit the significant barriers. The yellow quadrant indicates a lack of high-level scientific and technological capabilities, plus a number of growth points and many more obstacles to development than in the first two cases. Red
quadrant indicates a lack of high-level science and technology development, with much greater obstacles than the growth points.

Canada, Germany and the United States dominate with a large gap. They are characterized by the lowest barriers to scientific progress (in the U.S., though there are more obstacles than the first two countries). It is followed by Australia, Japan, Korea and Israel. The potential for the development of science and technology in China, India, Poland and Russia is much more modest. In these countries a lot more obstacles to development are present, which will certainly be a factor undoubtedly limiting a high scientific and technological potential of these countries. Brazil, Chile, Mexico, Turkey, South Africa, Indonesia and Colombia follow behind them. With respect to the chosen 11 developing countries, the possibilities of development are evaluated as very modest (see Fig. 8).

3.3. Forecast of Russian Institute of Economic Strategies.

In 2006, the Institute for Economic Strategies (Russia) published a report «Forecast of innovation, technological and structural dynamics of the economy of Russia until 2030, taking into account global trends». This report attempts to identify trends in the development of the national economy over the next 25 years.

The authors analyze two main scenarios for the development of national economy: inertial and innovative - breakthrough. Given the risk of depopulation in Russia, exhaustion of the best mineral deposits and growing economic dependency on exports of fuels and raw materials, the report's authors believe innovative - breakthrough scenario is the only alternative that meets the challenges of the XXI century. They suggest the following conditions for the implementation of innovative-breakthrough scenario (see Fig. 9).

![Figure 9. Conditions of innovative-breakthrough scenario realization](image)

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The authors mention six conditions:

1) The revival of long-term scientific predictions.
2) Forward-looking public policies.
3) Establishment of innovative partnerships between government, business, science and education.
4) Implementation of institutional transformation, enabling a breakthrough innovation.
5) Provision of opportunities for the law of change of generations.
6) Ensure the priorities of national interests in the development and implementation of long-term development strategy for Russia and the ongoing business\textsuperscript{31}.

Innovative-breakthrough scenario recognizes that on the basis of long-term scientific forecasting the state strategy is developed. It includes government programs and projects. For their realization it is necessary to carry out a complex of institutional transformations with the account of a priority of national interests (see Fig. 10).

Such strategy assumes innovative cooperation of science and education. Together with the state and business they create national programs and projects. Such cooperation creates preconditions for innovative orientation of all civil society and is pledge of successful realization of innovative-breakthrough scenario.

Figure 10. Innovative partnership of government, business, science and education


Innovative partnership already announced during realisation of national programs. Largest of them are:

1. Investment in transport infrastructure, provided the transport strategy of Russia (2006-2020);
2. The state program of armaments for 2007-2015. - Program development and procurement of equipment for Russia's Army;
3. The stated program of building 40 new nuclear power units;
4. Program development of gas fields of Yamal Peninsula;
5. Capital investments in the program of development of gas fields in Eastern Siberia and the Far East (intensive version);
6. Capital investments in the development program of main electric networks in Russia at 220 kV and above in the period up to 2013 (see Table 7).
Table 7. Public investment program to modernize certain sectors of the economy

<table>
<thead>
<tr>
<th>PROGRAMS</th>
<th>FUNDING REQUIREMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment in transport infrastructure, provided the transport strategy of Russia (2006-2020)</td>
<td>The annual volume of financing - $ 20 billion</td>
</tr>
<tr>
<td>The state program of armaments for 2007-2015. - Program development and procurement of equipment for Russia's Army</td>
<td>Total funding - 4.94 trillion. rub., or 20.5 billion dollars per year</td>
</tr>
<tr>
<td>The stated program of building 40 new nuclear power units</td>
<td>Total $ 56 billion</td>
</tr>
<tr>
<td>Program development of gas fields of Yamal Peninsula</td>
<td>Total $ 70 billion</td>
</tr>
<tr>
<td>Capital investments in the program of development of gas fields in Eastern Siberia and the Far East (intensive version)</td>
<td>Total 40-56 billion dollars (based on different scenarios)</td>
</tr>
<tr>
<td>Capital investments in the development program of main electric networks in Russia at 220 kV and above in the period up to 2013</td>
<td>Total 12.6 billion</td>
</tr>
</tbody>
</table>


The most vulnerable place of the projection of Institute of economic policies is that the authors do not describe the mechanism of its implementation. They believe that it is necessary «to refocus on innovation and breakthrough way, as private capital, and public authorities at all levels», but, unfortunately, are not as practical to do, how to create the institutional preconditions for the realization of their grand plan.
Figure 11. Forecast of Russian economy sectors dynamics (%).


Figure 12. Rate of technological ways and equipment changing in vanguard countries
Therefore, let’s try to formulate the tactical priorities for the coming years. Scientists and political movements claiming to be the leaders of Russia's modernization should formulate specific actions that would indicate a general vector of the changes, allow a rapid positive effect and find support from a wide range of fellow citizens.

![Diagram: Basic directions of Technological Tenor](image)

**Figure 13. Basic directions of Technological Tenor**

Financial resources from selling the fuel and raw materials, could be used for the development of advanced technologies. The authors’ of «... Russia's economy forecast to 2030» believe that under the inertial scenario public sector share should decrease from 31% in 2004 to 19% in 2030, while the share of big and medium business should increase from 41% in 2004 to 49% in 2030, and the presence of foreign capital should double (from 8 to 16%, respectively, see Figure 11).

The implementation of innovative-breakthrough scenario will lead to an increase of the share of the public sector by 2030 to 34%, big and medium business share should decrease to 38%, the share of foreign capital should decrease to 6%, and small-scale product should grow from 8% to 14%. This means that the leading role in implementing innovative scenario the authors give to the state. It, from their point of view, must assume the bulk costs, both in production as well as in the social sphere, to act as a strategic investor in key sectors of the economy.
Figure 14. Forecast of Russian economy institutional structure dynamic (innovative-breakthrough scenario, technological tenor, share in total output in producer's price, %).


Authors of Strategy of Russian Economic Strategy Institute pay attention to technological side of questions. They analysed the big Kondratyev’s cycles during the XX-XIX centuries (see Fig. 12). They give special attention to the period from 1990 for 2030. During this period there is a change of the IV, V and VI technological ways (see Fig. 13). In 1990 in Russia the III and IV ways dominated. On them 37 % and 51 % (correspondingly) of cumulative GNP were necessary. In 2000 because of economic recession their share remained almost invariable (35 % and 54 % correspondingly). Nevertheless in 2010 the share of the IV way has raised to 60 %, and V way has considerably pressed the III way, which share increased from about 4 % in 2000 to 17 % in 2010.

If the planned forecast is realized the V way will increase up to 40 % to 2030 year and it becomes a leading way (see Fig. 14).
Figure 15. Export clusters of Russia: 1997-2005.


However, not all scientists look at an increase of government’s influence with optimism. Michael Porter and Christian Ketels also understand that the strengthening of the state is inevitable. But they give it a different role. U.S. scientists believe that the primary role of government is to strengthen macro-economic, political, legal and social components of the institutional environment. From the point of author’s view, it is necessary to:

- «Create an efficient and independent legal system. Creating sound procedures to enforce the law and protect individual rights is necessary for increasing the credibility and impact of government policies. Crucially, the government needs to resist the temptation to interfere with the judiciary, even when decisions might not go in the direction it prefers. Given its legal system shortages, Russia should work with international organizations and agreements, such as the WTO, to ensure credibility of adherence to policies.
• Improve the capabilities and professionalism of political institutions. Stronger government institutions, with a system of checks and balances, are the only effective way to achieve political stability. Political reform in this direction will be complicated but necessary. Ensuring orderly transfers of power, and continuity in policy direction, are especially crucial.

Figure 16. Growth possibilities based on strong export clusters of Russia in 2005


• Use competitive principles to improve the delivery of public and social services. Improving public and social services is needed to increase productivity and will be essential to engaging the support of the majority of Russians for further economic reforms. One priority is to reform the health care system using value-based competition principles. Among other steps, health care provision could be opened up to both public and private providers to drive a step-change improvement in health care delivery and open up a huge new market for entrepreneurship»32.

32 Porter M., Ketels K., 2007. p. 82-83
It means that administrative transparency, professionalism, and efficiency should be improved. “With a more reliable and efficient administration, corruption will decline, the costs of doing business will fall, uncertainties and delays that hinder investment decisions will be reduced, and competition will rise. There is an urgent need in Russia to reduce, simplify, and streamline rules and regulations at all levels of government. Past incremental approaches to administrative reform have not succeeded”.

They offer a whole system of measures to increase competition in the economy, with a view to streamlining and limiting the role of government in the economic sphere. In their view, it is necessary to intensify the process of international trade and investment of foreign capital, as well as to encourage competition between regions. Economic ties with the neighboring countries, the report considered unproductive. Russia could benefit by establishing mutually beneficial economic relations with all neighboring countries.

According to the authors Russian economic policy should be developed under three broad themes: “First, Russia needs an overall national economic strategy for the economic direction it wants to take. Second, Russia must upgrade the foundations of competitiveness through concerted efforts in strengthening context, improving the general business environment, supporting cluster development, creating competitive regions, and developing productive economic linkages with neighboring countries. Third, Russia needs to define a growth path which is based on its strengths and which will diversify the economy from its extreme natural resource dependence”.

![Diagram](image_url)

**Figure 17. Growth possibilities in connected clusters in Russia (according to M. Porter).**


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33 Ibid. P. 84.
34 Ibid. P. 80
M. Porter’s and C. Ketels’s report «Competitiveness at the Crossroads: direction of the Russian Economy» shows percentage change in the Russian Federation in 1997 - 2005 cities; most attention they have given to the development of clusters. According to the authors, «Clusters are a natural manifestation of the role of specialized knowledge, skills, infrastructure, and supporting industries at a particular location in enhancing productivity, innovation, and new business formation»\(^{35}\).

Figure 15 shows that the share of the oil and gas industry significantly increased, as well as the extraction of metals and primary metal products. At the same time, these clusters dominate today's Russia (see Figure 16), hampering the harmonious development of other economic sectors. To follow the authors’ advice, Russia has to continue to focus on oil and gas production and primary processing (plastics and chemical products), forestry (decorative materials, construction equipment, construction, woodworking and furniture production), as well as industrial equipment, necessary for their production (see Figure 17). The last area of potential growth is the metallurgical industry. Only it produces what might be called a «new economy» (motors for space vehicles, automobiles, and certain types of industrial equipment).

M. Porter and C. Ketels believe that in the nearest future, Russia will retain its resource specialization and hardly has a chance for harmonious development of various clusters, typical of developed countries.

Their pessimism is based on the situation doing business in Russia for the last several years. It has not improved during last four years. If in 2008 Russia occupied 112 rank in 2011 it has moved on to 123 rank (see Table 8). It testifies about high transaction costs. Without their reduction fast moving to an innovative way of development is impossible.

Table 8. Doing business in Russia (2008-2011)

<table>
<thead>
<tr>
<th>Ease of...</th>
<th>2008 rank</th>
<th>2009 rank</th>
<th>2010 rank</th>
<th>2011 rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Starting a Business;</td>
<td>52</td>
<td>65</td>
<td>104</td>
<td>108</td>
</tr>
<tr>
<td>2. Dealing with Construction Permits;</td>
<td>180</td>
<td>180</td>
<td>182</td>
<td>182</td>
</tr>
<tr>
<td>3. Employing Workers;</td>
<td>100</td>
<td>101</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>4. Registering Property;</td>
<td>46</td>
<td>49</td>
<td>45</td>
<td>51</td>
</tr>
<tr>
<td>5. Getting Credit;</td>
<td>102</td>
<td>109</td>
<td>87</td>
<td>89</td>
</tr>
<tr>
<td>6. Protecting Investors;</td>
<td>84</td>
<td>88</td>
<td>92</td>
<td>93</td>
</tr>
<tr>
<td>7. Paying Taxes;</td>
<td>136</td>
<td>134</td>
<td>103</td>
<td>105</td>
</tr>
<tr>
<td>8. Trading Across Borders;</td>
<td>162</td>
<td>161</td>
<td>162</td>
<td>162</td>
</tr>
<tr>
<td>9. Enforcing Contracts;</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>10. Closing a Business.</td>
<td>83</td>
<td>89</td>
<td>93</td>
<td>103</td>
</tr>
</tbody>
</table>

Doing Business                   112  120  116  123

\(^{35}\) Ibid. P. 13
4. Strategy and tactics of Russia's modernization in the light of the concept of social market economy

According to the analysis above there are some recommendations which can be offered. But we should take into account the mistakes which were done in the past. Economic policy should not be formulated with an emphasis on "restoration" and "survival". It shouldn't build on the opposition of market and democracy, on the one hand, and social justice, on the other hand. There is a wrong way to build the economy on the opposition of government and the market. Economic policy shouldn't focus on any one social group: the poor people, entrepreneurs, Russians and so on. On the other side, it shouldn't be based only on quantity indicators ("Double the pace of economic growth", “To catch up and overtake America in performance” etc.). Nostalgia for the Soviet Union of the past should go out.

We propose that the model of social market economy can be used for Russia in the 21st century. Basic elements of social market economy are personal liberty, social justice and economic efficiency.

**Personal liberty** assumes trust strengthening between agents, development of guarantees of private property, and regular economic policy promoting freedom.
- building trust between subjects
- development of guarantees of private property
- systematic economic policies that promote freedom

With **social justice** present market economy promotes social development and strengthens middle class. Democracy will be allowed to break administrative barriers and to create public control. Social justice also includes support of vulnerable regions of Russia.
- Premise - raising living standards.
- Necessary to form a nationally oriented leading stratum of society:
  - “Offshore aristocracy”, which moved its capital to foreign countries.
  - *The bureaucracy, which gradually turns from the Soviet nomenklatura to the competent state. Employees.*
- In the formation of the national elite, an important role to play in the modern system of education and culture.
  - *Stratification of Russian higher education reinforces and reproduces the differentiation of post-Soviet society.*

Even in the Soviet Union there was more opportunity for representatives of regional centers to break into the top of the pyramid.
- Send a market economy at the service of social.
• Poor can be allowed, to live in dignity, we must act together.
• Basis of Russia - the middle class.
• To break administrative barriers, create public control.
• Encourage «regional engines of growth».
• Provide targeted support to vulnerable regions and ensuring them conditions to improve the quality of life as one of the criteria for the integrity of Russia.

**Economic efficiency** should be directed towards creation and maintenance of competitive order, strengthening of antimonopoly activity and improving fair entrepreneur’s image. This will make Russia more attractive for workers from abroad and help it develop integrative relations with neighboring countries ("economic recovery of a single post-Soviet space").

The following requirements for effective economic policy can be offered to reach the market economy. It should be understandable for citizens. Politicians must convince the people of its (politics) total accuracy. Policy must be consistent, open and honest. It should be tactically constructed in the nearest future: directed not only to a long-run final result, but also convincing demonstrational effect within reasonable time spread according to expectation of population.

All these measures will raise economic efficiency while creating preconditions for fast overcoming of the crisis and increasing the welfare and the acceleration of economic development of Russia.

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Lessons from the age of post-war economic miracle in Japan

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Why has Japan developed economically so rapid after the world war II in spite of a very poor country in natural resources? And now why is Japanese economy suffering from the long-term economic slump? These issues are not only very critical for the Japanese economy, but also might give various suggestions for the countries of now booming economies.

The post-war economic miracle started from 1955 and ended at 1991 in Japan. This period is divided into three terms, from 1955 to 1973, from 1973 to 1985 and from 1985 to 1991. And after 1991 Japan is in continuing distress with the slump.

Figure 1: Change of GDP

I. First term of the economic growth

In the first term Japanese people enjoyed the marvelous economic growth of more than 9% on an average until the oil crisis of 1973.

This period features (1) rich manpower, (2) high savings rate and investment, (3) higher level of consumption (especially durable consumer goods), (4) the fixed exchange rate system, by the really depreciating yen for the US-dollar by getting higher productivities.

This chart indicates obviously the dramatic change of Japanese GDP.
(1) Rich manpower.

The economic growth depends strongly upon labor force. One economy demands manpower in own country, other in foreign countries. For example West Germany relied on the foreigners (so-called the guest-workers, mainly from Turkey) to make up for shortage of labors since 1960’s. In Japan local districts across the country supplied the young and active manpower to the big cities as the tractor of the economic miracle. They left mainly for Tokyo, Osaka and Nagoya. The population of 1950 was allocated to Tokyo district 15.5%, to Osaka district 10.7% and Nagoya district 10.5%, and in 2008 27.4%, 13.3%, 11.6%, respectively. Thus there were the huge reservoirs of labor force in the rural areas and fishing villages at the first term.

Young Japanese workers had much more merits compared to the guest-workers.

(a) There were scarcely the cultural conflicts on the job due to the same language and the racially homogeneous nation.

(b) They often identified the growth of company as theirs.

(c) The prosperity of company was capable of raising wages. This factor also motivated to work devotedly.

(2) High savings rate and investment.

Figure 2: Comparison of savings rate of household US

![Chart showing savings rate comparison]

This chart indicates during the first term how high the Japanese savings rate was.

As the chart suggests, the Japanese savings rate was extraordinary higher compared with other countries. These savings were invested in various fields, for example in the iron-steel industries, home electronics, cars and so on. As for technology, at first Japan learned much from US and caught up and overtook US later. The result was the economic miracle.

(3) Higher level of consumption.

With the raising wages Japanese workers consumed more and more, and the durable consumer goods were abundant in the domestic markets. They felt they were in the middle class. About 90% of Japanese had the same well-to-do feeling in the late 1980s.
Figure 3: Higher level of consumption

(4) The fixed exchange rate system.

The exchange rate system was fixed under IMF in the first term. Under this system the rate was 360 yen versus one dollar till 1971, so-called Nixon shock (cancellation of the convertibility of US dollar to gold). This fixed rate was very comfortable for the rapid growing Japanese economy. Japanese export-led economy was very successful in US markets, but soon after brought out serious economic conflicts with US.

Figure 4: Fixed exchange rate system

II. Second term of the economic growth

Japanese economy overcame a lot of difficulties in the direction of the stable economic growth (4.2% on an average). In spite of that the fixed exchange rate system had fluctuated and the yen rate appreciated to the dollar, and moreover the oil crisis occurred two times with the stagflation, Japanese economy succeeded in lowering costs by the rationalization of management and the technological efficiency.

III. Third term of the economic growth

But the Plaza Accord of G5 in 1985 chimed coming up to the end of economic miracle. The US dollar depreciated sharply especially versus the yen by this agreement. The yen value doubled rapidly to US-dollar.
Japan worrying about the high yen recession changed the economic policy decisively from the export-led growth into the expansion of domestic demand. The Japanese government focused especially on the building of houses and the development for resorts in the local regions across Japan in order to avoid the effects of the too severe strong yen. At the same time the Bank of Japan reduced drastically the interest rates. As a result the real estate prices rose sharply and the stock market boomed extraordinary by these stimulating packages. In this way Japanese economy became speculative and bubbled. But the consumer prices were relatively stable due to the cheaper export goods by the rising yen. Almost all Japanese people were so satisfied in this economic situation that about 90% of them had the middle-class-feeling.
On the other hand, the US exports to Japan were not successful in spite of the steep dollar depreciation. Therefore, USA demanded Japan more severe measures to import American goods. According to the bilateral agreement Japan had to solve structural problems that stood as impediments to trade and balance of payment adjustment, and moreover to invest the enormous sum of money in local infrastructure. These agreements between Japan and USA became greater burdens for Japan after the burst of bubble.

When the Japanese economy collapsed unexpectedly in 1991, the surroundings of Japanese economy had totally changed.

(1) The burst of bubble followed the severe slump which reached the peak of the serious financial crisis of 1997-8. Especially real estates financed by banks were hit severely by the crisis and became bankrupt.

(2) In just this economic situation the yen began to increase rapidly to the dollar. The dollar got unstable due to the failure of the US investment policy to Mexico and fled into Japan. The yen value to the US-dollar raised 80 yen in a moment in 1995. The Japanese economy was badly damaged by the strong yen again.

(3) The de-industrialization began to proceed. Many Japanese manufacturers removed their factories to China etc. for lower wages one after another.
Moreover the countries as BRICs have economically emerged with the end of the cold war. These countries are now getting more powerfully competitive against Japan.

The long-term and social structural problem is in terms of demography. It is the declining birthrate and at the same time the aging. These demographic phenomena appear especially in the local economies. Many streets of local cities are deserted because the shops close one after another, and in the rural aging areas the population is rapidly decreasing. Many mountain villages are dying. The once huge reservoirs of labor force are dried-up completely.

In confronting these serious problems Japan is groping for an answer to resume the new economic growth.

Figure 9: So-called shutter-street

Conclusion.

As conclusion of my paper I want to point out three issues.

(1) **Domestic problems**

Even now Japan is getting separated clearly and widely between the overpopulated cities (especially around Tokyo) and underpopulated areas. The reservoir of labor force gets dried-up because of the declining birthrate of the big cities and the aging of the rural areas. We should have had to consider ways of some reasonable distribution of population by fostering local economies before the drying-up of the reservoir of labor force.

(2) **Overseas problems**

Japan kept attaching importance to the bilateral economic relationship with USA till the collapse of bubble. But afterward the economic and political surroundings around Japan are changing dramatically. Now Japan should consider and act multilaterally and globally.
(3) Vision of policy makers and statesmen

Lastly a statesman with the wide and historical perspective or vision is now wanted because the world today is full of too complicated problems.
Dr. Svetlana Kirdina making her presentation
New State Corporations as Next-Generation Institutional Forms of S&T Policies in Russia

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The objective of the paper is to present the new institutional form of State Corporation that is non-profit organization under government regulation. This form has been widely developed for the last 4 years in Russia. The main sphere of State Corporations activity is high-tech development. The share of State Corporations in the state budget is more than 20% and it is constantly increasing. At the present stage of modern Russian economic reforms new State Corporations are the least risky institution, which can answer the needs and challenges of innovative modernization.

The Institutional Analysis of Modern Russian Economic Reforms

The essence of Russia’s economic reforms in 1990-2000 is the search for an optimal combination of market (or “liberal”) and redistributive institutions and modern forms of their embodiment.

By the middle of the 1980s, on the eve of perestroika (term of the Soviet Union) or move to a transition economy (term of world social sciences), Soviet Union had an imbalanced institutional economic structure. It manifested itself in the predominant and active development of centralized institutions in a redistributive economy only. Market institutions, which were necessary for the successful growth of the economic system, were under-developed and existed as latent, shadowy or illegal forms only. Such an imbalance in the end resulted in an inefficient social system and led to a large decrease in the nation’s economic and social parameters. The need for system reconstruction and rearranging the institutional structure was recognized in Soviet society.

We can distinguish two main stages in the transition process during that period. The first one started in the middle of the 1980s when new political leadership (i.e. Michail Gorbachev, the General Secretary of the Communist Party of the Soviet Union 1985-1989) and the first USSR President (1990-1991), and then the first Russian President Boris Yeltsin (1991-1999)) began to develop market-based institutions with legislation. From the mid-80s, new market institutions began to be implemented:

- Privatization (in different forms) of the majority of state-run enterprises and all state-run middle and small enterprises was put into practice to create private ownership. What was privatization? Each citizen received a voucher as a right to a ‘share’ of public property. The process of concentrating vouchers began and gave rise to the first ‘capital’ formations;

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36 This work is supported by the Russian Foundation for Basic Research, project № 09-06-00052a
Decentralization in the economic governance system was made to develop exchange transactions instead of redistribution. The state planning system (“Gosplan”) and rigid connections between economic agents were liquidated. Price management was stopped;

New laws about the creation and liquidation of new enterprises and small business in all branches of economy (from finance and banks to trade and services) were passed to develop competition;

Contract labour substitutes were enacted for employed (unlimited-term) labour because the state system of manpower training, and distribution and guaranties was liquidated. Relationships between employees and employers became the subject of contracts. Both state salary management and price regulation were cancelled;

Profit maximization became the main criteria for new enterprises and their owners began acting in an open and competitive market environment.

Nevertheless, the attempt to completely replace redistributive institutions by market ones failed, as we know now. This is evident because there was neither growth in total efficiency of economy nor expected efficiency increases in new companies of that period. In 1998, after Russia’s national default the state economic policy was turned to searching for an optimal and balanced combination of related market and redistributive institutions.

Since the late 1990s and early 2000s (i.e. when President Vladimir Putin and new political leadership took office), more attention has been paid to the modernization of redistributive institutions rather than to implementing market institution as before:

Supreme conditioned ownership institutions show up in the creation of large-scale joint-stock companies and holding structures under management (or with control share in capital) by the Russian government or regional governments. Such companies are mainly present in infrastructure building, housing management in cities, information and communication or high-tech branches, including gas, petroleum and energy production, as well as transportation, including railway transport, the motor-car industry, space and aircraft construction, etc.;

Redistribution was presented in new National Projects under federal governance and is supported by the federal budget. These projects cover the main spheres of human living, namely education, public health, housing and

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37 In China such balanced approach took place from the beginning of economic reforms in later 1970-s. It is one of the main courses of their successful «planned economy with market regulation» policy (The China Society Yearbook, 2009:37). This is what we supposed (Дерябина, Кирдина, Кондрашова, 2010).


39 This term introduced by Karl Polanyi (Polanyi, 1977).
agriculture. The centralization of National Projects Management on the new level puts the redistribution scheme (accumulation-coordination-distribution) into action. National projects have added to the system of Federal target programs and other forms of centralized state support in various fields of activity, which have become more and more, especially in connection with the financial and economic crisis of 2008-2009;

- **Cooperation** is offered wherein the state supports creating economic structures in which enterprises interact on the basis of not a competition, but also cooperation. In detail below is considered the case of state corporations (StCorps), actively introduced in 2007, which illustrates this tendency;

- Developing **employed (unlimited-term) labour** is expressed in the following: 1) organizing industry specialists in the education system on the basis of private-and-public partnerships with the state retaining its leading position; 2) new labour policy that is primarily oriented towards the wealth of people working in the so-called “state budgetary financed area” of the economy; 3) growth of non-monetary factors of labour rewards (which is peculiar for the system of employed labour);

- **Cost limitation (not profit maximization), or X-efficiency**\(^{40}\) is expressed in price and tariffs regulation, both at federal and regional levels. The main objective of corresponding commissions (in electric power, railway transport, housing service) is not revenue of the companies but rather decrease of general resources and manpower used, as well as national product expenditure and total cost of its production. Governmental pressure to reduce the level of credit rates for the state, and non-state banks also testifies to expansion of the sphere of action of this X-efficiency institute (for more detail see Вержников, Кирдина, 2010).

As a result, a new balance of redistributive and market institutions is being created in Russia at present. The re-development of redistributive institutions in the social structure of Russia along with further support of market institutions has formed a more balanced (in favour of the former) institutional structure. The process of this formation has gone along with the recent growth of economic and social development indexes in Russia. In April 2008 (i.e. before the world financial crisis) Russia occupied 8\(^{th}\) place on the national GDP index, compared to 18\(^{th}\) in 2005.

But the crisis has shown that Russian development was neither stable nor self-dependent. In 2009, Russia had a GDP decrease of more than 8\%. In comparison, the Indian and Chinese economies in 2009 resumed growth at about +7 and 10\% respectively. Another member of BRIC - Brazil - also had positive growth. The average level of GDP decreases in the USA, Japan and the Euro zone was less than minus 1\% (Sources: IMF, Bloomberg).

Why has the Russian economy not proved resilient? Delayed institutional stabilization actions and the backwardness of the post-Soviet economic structure, based mainly on raw material exports, has resulted in the unsteadiness of Russia’s economic development. The crisis of 2008-2009 has shown that we are dealing with long-term,

\(^{40}\) This term introduced by Harvey Liebenstein (Liebenstein, 1966; 1978).
serious problems, namely, the inefficiency of institutional and economic structures. Up until the crisis, neither institutional nor structural modernization was carried out sufficiently or successfully.

**From a raw materials economy to a hi-technology economy**

Though gas and energy carriers still remain major Russian exports, Russia is now actively working out new S&T policies and the strategy of hi-tech sectors development. Ever since 2002, the target of the state policy has been transition to an innovative way of Russia’s development. Forming the National Innovation System (NIS) is an integral part of state economic policy (Lenchuk, 2006).

What were the initial conditions? Unfortunately, the structure of the Russian economy has changed notably over the period of market transformations: technological shifts have been obviously regressive. There was a washout of innovation intensive manufacturing industries in favour of mining and raw materials processing branches that practically do not give any impulses to innovation development. In addition, a huge brain drain of potential innovators in science and technology was taking place. Emigration amounted to nearly 1 million people in 1990-2000s or more than 10% of the able-bodied population.

Despite the losses suffered during the transformations from a planned economy to a market-based economy, Russia continued to possess one of the largest scientific potentials in terms of its scientific workers, lagging behind only the USA, Japan and China. The goal for the NIS was to actualize and develop this one world-class scientific and technical potential.

During the first stage of creating the new NIS (2002-2006), the Russian government oriented itself to institutional models tested by world practice in developed countries. But neither businesses nor the state could successfully carry out these models. Here is a list of points criticized in developing the NIS in Russia during these years:

- Attempts at mechanically transferring foreign experience (first of all, from the USA) to Russia for organization of research, development and education system did not take into account the real conditions and history of Russia’s development;
- There was no single governmental body which was responsible for developing, regulating and defending the intellectual property rights of innovation policies involved in the new system;
- There was no integral approach to information processing and knowledge transfers in the NIS;
- Coordination between the state and private sectors in developing priorities and measures for establishing financial support of potential research work was weak;
- The activities of large and small enterprises involved in science and business development of high technologies was low.

At the beginning of 2006, conceptual approaches to forming the NIS were changed and became more diverse. The main emphasis was laid on the role of increasing
and concentrating federal financial support and regulation on activating state-private partnerships. In fact, a different institutional design was proclaimed.

Stronger state financial support and regulations during the second stage of NIS started by forming new financial institutions for innovation development (e.g. the Federal Law of “Bank for Development,” adopted in 2006). The Russian state would try (as promised) to completely finance all infrastructure needed for special economic zones, including technical and promotional zones and techno-parks. On January 1, 2008, special measures aimed at forming a more favourable innovation climate were proposed for execution.

What were the main directives for activating state-private partnership mechanisms? The Federal Target Program (FTP) – «R&D along priority lines of developing the Russian scientific-technological complex in 2007-2012» – provides for more active participation of the private sector. Practically all innovation projects in this program are to be financed by the state jointly with private business. The volume of the required off-budget (i.e. non-federal money) co-financing varies depending on the type of project: for researching and developing technologies, co-financing is set at 20-30% of the project’s cost and commercializing technologies is set to 50-70%.

State Corporations as new institutional forms in S&T policies

The modern forms for concentrating state resources in hi-tech branches in Russia are now called State Corporations (StCorps). An integral part of the NIS is in establishing StCorps in the most competitive branches of the economy: nanotechnology, aircraft-building, space, nuclear power-plant, engineering, shipbuilding, and defence of the industrial complex. Within the framework of these fields, federal target programs are formed and questions of funding concrete innovative projects are worked out.

The creation of StCorps in Russia was the first response to modernization challenges and making effective investments in the high-tech industry. The development of StCorps implied that these businesses could become the locomotives of a breakthrough in the domestic economy.

Russian legislation defines that StCorps can be set up in any sphere that is crucial for the nation. In general, they are made to solve problems in spheres that have a significant role for national, social and economic development or for national security; i.e. high risks, with a low rate of return on capital and for large-scale mega-projects. A StCorp is legally a non-profit foundation (i.e. organisation) responsible for the more effective use of managerial and financial resources. The scope of powers and resources, which are allocated by the Federal Government to StCorps, is greater than resources allocated to existing stock-share companies with 100% state capital.

As for the National Innovation System, StCorps have a special role. First of all, StCorps are established with the aim of healing damaged economic ties in high technology industries and consolidating enterprises with a certain kind of branch profile. StCorps are designed to improve the competitiveness of Russia’s products on the world market by introducing modern technologies. We know that large consolidated companies have a greater capacity to invest in S&T development than small ones, which is another reason for implementing StCorps. And last but not the least, scientific development
requires long-term investments, namely, federal budgetary funds are intended to establish "long" money for today's StCorps.

There have been many opinions on the role and prospects of StCorps in Russia. Some economists consider them as unnecessary and a strange form of organization. This opinion was very popular especially before the financial crisis in October, 2008. In spite of that, our analysis conducted at that time (Кирдина, 2008) showed that StCorps were logical and 'natural' for Russian conditions and would probably serve as the long-term institutional form. This analysis was made on the basis of Institutional Matrices Theory or X- and Y-theory (Кирдина, 2000/2001; 2004; Kirdina, 2001; 2003).

As for the history of establishing StCorps, the article “On State Corporation” amended a special federal law “On Non-Profit Organizations” on July 8th, 1999. The goal of StCorps was clearly defined as: “the implementation of social, governing and other publically useful functions”. The entrepreneurial activity of StCorps is performed only for the sake of the goals it was created for, but not for gaining profit. Each StCorp must be created and grow in compliance with a special federal targeted law, which was passed for this purpose. This law is considered as a Constituent Document for every StCorp. Provisions of the federal law “predominate over the provisions of the Law “On non-profit organizations”, which are applied only subsidiarly”.

The commissioner of every StCorp is the Russian Federation, represented by the Russian Federal Assembly, which passes and approves laws establishing StCorp. The treasury of the Russian Federation contributes assets. In the case of liquidating a StCorps, the real property is transferred to the owner, which is the State. The Accounting Chamber of the Russian Federation controls property usage. Each StCorp has to issue an Annual Report in the official federal mass media, such as “The Russian Newspaper”.

In spite of the fact that legal forms of StCorps have been known for over 200 years in western countries, the idea of such a special StCorp was borrowed by Russia from China. This legally “sleeping” form started to be implemented in Russia only in 2007. The reason given for creating StCorps was the inefficiency of domestic investments in Russia’s economy. According to expert company reviews, 1% growth of assets per employee gave only a 0.4% growth in his or her productivity. The idea of setting up holding companies, which had been popular in Russia before 2007, failed. A holding company is a profit-oriented economic structure, more consistent with the market institutional structure. It had been planned in Russia to set up 37 holding companies from 2002 to 2008, but in reality only 17 such companies were created.

As for StCorps, they are rapidly developing in the Russian economy and society. In March 2008, the share of StCorps in the expenditure of State budget was 17%, while accounting for 22% of its income (Государственные корпорации в России, 2008). At present, there are about 10 State Corporations, which have been created to solve the most important investment-demanding problems. For example, «VneshEconomBank» was created in May 2007 to ensure the enhancement of competitiveness in the economy; «RosNanoTech» was set up in July 2007 to develop new nano-technologies; «The

41 Before that only one state corporation «The federal agency on insurance of individual bank accounts» was created in January, 2004.
foundation for reform of the housing sector», also started in July 2007, with the aim of modernising residential housing utilities; «OlimpStroy», in October 2007 to develop the future Olympic Games constructions; «RosAtom», in November 2007 to modernise the economy’s nuclear sector; and «RosTechnologies», in November 2007 to support the production and export of the high-tech industry, etc. It is expected that StCorps will be set up in the finance sector and also in other branches of industry.

Recently the head of the «RosTechnologies» StCorp said 42 that the corporation was modelled on the Italian group of companies Finmeccanica, established in 1948. The prototype of this group of companies was the State Institute of Industrial reconstruction (Istituto per la Reaconstuzione Industriale, IRI), created by Benito Mussolini back in 1933. Now the company occupies place Number 1 in high technology in Italy and 3rd place in Europe, with 16% of the company’s revenue invested in R&D 43.

Our institutional analysis shows that modern Russian StCorp correspond to the nature of redistributive economy according to their key parameters. Here are the summary proofs of this situation:

- It is possible to set up a StCorp only according to the special law of the Russian Federation. StCorps report to federal executive bodies, which appoint the StCorp’s General Director and form the Supervisory Board. The state controls the assets of StCorps. In case of their liquidation, all assets are to be returned to the state, as the owner of these assets. These features correspond to the performance of *Supreme Conditioned Ownership institution* of a redistributive economy;

- StCorps have a hierarchical structure, which implies not only the division of labour functions and responsibilities between the levels, but also the organizational and financial subordination according to the level of hierarchy. This corresponds to *the Redistribution institution* of a redistributive economy, i.e. where the economic center has both a leading and mediating role;

- Technologically dependant enterprises and enterprises belonging to the same industrial profile are incorporated into a single definitive StCorp. This is done so that the enterprises will not compete with each other, but rather so that they will consolidate their performances and business activities. Such a model corresponds to *the institution of Cooperation* in redistributive centralized economies;

- Profit making cannot be the main aim of a StCorp; this corresponds to *the institution of Cost limitation, or X-efficiency* (in contrast to a profit maximization).

We can see that Russian StCorps do not correspond to typically western standards or expectations. Instead, they correspond to the dominant national institutional framework in Russia with its mainly centralized and

43 http://www.finmeccanica.it
redistributive economy. This dominant form is the result of a long period of successes and failures in Russia’s economy, society and politics. At the same time, StCorps are a «market-influenced» institutional form, in that they got their particular orientation in the light of experiences and interactions with the liberal market environment (e.g. share capital, budgetary principles, etc.), which is not its opposition, but rather its structural compliment.

Furthermore StCorps have a high potential, not only as «breakthrough» institutions in Russia’s national economy, but also as structures that provide new opportunities for mobilizing both public and private capital working together. StCorps can cooperate both based on market terms (i.e. on the global market) and on state-administered terms (i.e. domestically). The legal mechanism to solve pressing economic and social problems were lacking before the creation of StCorps.

Contrary to the Federal State Unitary Enterprises, the aim of which was to implement Federal Target Programs (FTP), StCorps are supposed to become more financially efficient market players because they have the legal right to secure internal and also foreign loans, to issue bonds, etc. StCorps are thus better partners for the private sector because they have the opportunity not only to have “principal-agent” relations, but also mutually implement different projects on the basis of “public-private” partnerships. For instance, StCorps do not have any legal restrictions on purchasing products and services, which was the case with FTP.

The first functioning years of StCorps identified the following problems:
- Neither clear goals nor clear focus on specific projects (i.e. "dispersion" of resources);
- Vague responsibility for the use of StCorps’ available funds and resources;
- Low efficiency and lack of performance evaluation parameters;
- Weak management and misuse of funds and property (e.g. mass media reported that the Accounts Chamber of the Russian Federation revealed financial irregularities such that it was ready to act with charges against StCorps. (But representatives of StCorps deny this information).

In our analysis, further «marketization and liberalization» as well as «redistributization» can help to solve these problems. As for StCorps’ «marketization», first of all it is necessarily to mention the transparency of their development. Taking into consideration the public character of StCorps, the standards of their transparency should be higher in comparison with ordinary stock-share companies. The fact that each StCorp is set up by a special federal law gives the opportunity to put such a ‘democratic’ transparency requirement into practice. Prospects for StCorps’ «redistributization» include the development of control and planning tasks for StCorps’ performance as well as implementing a system of indicators (i.e. measurements) to show the fulfillment of
these plans. Regular monitoring and control over the use of funds (e.g. state budget funds) by the Accounts Chamber is also strongly needed.\textsuperscript{44}

What is the future of StCorps in Russia? On the one hand, Russian President Dmitry Medvedev said regarding StCorps: “I do not think that this is the correct method of reforming our economic structure. In certain areas we really decided to use state corporations. But their life should be finite.”\textsuperscript{45} His governing team proposes instead to reorganize the StCorps into ordinary joint stock companies. On the other hand, the Ministry of Economic Development, Federal Financial Markets Service and Central Bank are preparing a bill to create a new StCorp called the “Russian Financial Agency” (RFA). Its main goal will be to improve management of state assets and liabilities. A Deputy Finance Minister Dmitry Pankin said in September, 2009: “While no governmental decisions on cancelling of state corporations are present, we have analyzed all legal forms and consider the most convenient variant to be the state corporation.” So, we see different views being put forward by government officials and agencies and must wait to learn what the next steps will be.

At the current time, a compromise proposal has been accepted for developing and improving the activities of StCorps based on their reorganization. In February 2010, the Ministry of Economic Development of the Russian Federation presented a corresponding plan for the government and the President of Russia. Changes were proposed in the organizational-legal form of StCorps: for them a special category was entered into juridical classifications of “legal entities under public law.” The proposal is to make joint stocks for StCorps, which will help to establish the government’s more effective control above the activity of the StCorps’ management.\textsuperscript{46}

Our institutional analysis of Russian StCorps leads us to suppose that this relatively new form is in fact a future trend that will assist in further transforming the high-tech industry. It also has the potential to become a much-needed answer to global technological challenges and challenges of innovative modernization. This is why we suppose that the quantity and capacity of StCorps in Russia (and also around the world) will increase. Russian StCorps represent a reproductive “matrix” with the basic institutional characteristics of a redistributive economy. At the same time, they are the result of institutional economic modernization based on responding to market reforms. The continuous reorganization (cf. modernization) of StCorps in Russia confirms this assumption.

**Findings and Conclusion**

In the early 2000s, Russia started to build an economy based on innovation. The country possesses one of the largest technological and scientific potentials (behind the USA, Japan and China), but its National Innovation System isn’t yet formed. Attempts at

\textsuperscript{44}“For the purpose of exercising control over fulfillment of the federal budget …. the Accounts Chamber of the Russian Federation is established” -The Constitution of the Russian Federation. Article 101, paragraph 5.


\textsuperscript{46} February 11, 2010 [http://slon.ru/articles/284882/](http://slon.ru/articles/284882/)
mechanically transferring western (i.e. foreign) experiences into Russia proved to be failures and not successes. A new institutional model for the Russian innovation system is now developing, by taking into account the real economic history of the country along with current institutional theory. Attempts to find an appropriate balance between redistributive and market institutions in contemporary Russian innovation policy are therefore continuing.

Establishing an effective proportion between redistributive and market economic institutions, is one of the important goals for Russian S&T policy. The “institutional character” of Russia fixes the limits of liberalization and needs the active implementation of market institution policies within a framework of modernizing and developing redistributive institution policies. Our institutional analysis of such new phenomenon as Russian State Corporations allows us to conclude that this relatively new institutional form is a future trend for transforming high-technology. It can become Russia’s answer to global technological challenges.

Our prognosis based on Institutional Matrices Theory (or X- and Y-theory) is the following: the Russian innovation system will move from the western-oriented institutional model to the Chinese one. This is because the Chinese model is more appropriate to adopt in the current Russian situation. The aim of Russia’s innovation policies must therefore look to balance between redistributive and market institutions, developing a successful combination that will help it move forward confidently as a sovereign nation, moving further beyond the shadow of its Soviet past in the 21st century.

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Social and Political Economy of Modern and Traditional Technologies: Some Conceptual Perspectives

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Abstract

Modern technologies have their roots in latest global developments in concept-based basic sciences and their practical laboratory based applications for economic and social needs. The global society's access to these applications is determined by their technical as well as their global economic and commercial viability. The institutions which influence these applications include the tastes and preferences of consumers, national and global input and output markets, globally networked scientific and R & D organisations, the industrial, service and agricultural organisations in the private and public sectors, and the national, international and multilateral S & T and economic policy-making bodies.

Traditional and indigenous technologies, on the other hand, have their roots in local markets, and expertise and experience accumulated and transmitted over generations of their practitioners. The society's access to these traditional technologies is determined by their technical viabilities, as well as by their local social and economic acceptability. The institutions which influence the society's access to traditional technologies are local consumer awareness and preferences, the networks promoting sustenance and development of traditional skills, and increasingly, due to the challenging convenience and economy of modern technologies, support from local, sub-regional and national public-governmental bodies.

This paper conceptually explores the socio-economic, developmental and environmental implications of modern and traditional technologies, illustrating them through distinguishing characteristics in selected products and processes. It concludes by suggesting the need to consider a balance between modern and traditional technologies in the background of their socio-economic, political-economic and environmental sustainability over the long run.

I Introduction

The basic objective of this paper is to conceptually delineate psychological, social, economic and political-economic distinctions between Modern Technologies (MT) and Traditional/Indigenous Technologies (TIT). Admittedly, MT and TIT increasingly inter-penetrate each other in a continuum. The paper attempts to highlight the contrasts, nevertheless, by focusing the discussion on selected illustrative extremes of this continuum.


48 Professor and Founder-Dean (Retd.), School of Management, University of Hyderabad, and Former L & T Chair Professor, Chairman (Economics) and Dean (Research), Administrative Staff College of India, Hyderabad.
Sections II and III outline the generally perceived definitional, conceptual and historical dimensions of the MT and TIT, respectively, to elicit their broad contrasting contexts for the following discussions. Beginning with a brief discussion of selected illustrative extremes of the TIT-MT continuum, Section IV draws on field-based local “artisanal” and global perspectives of their producers and users. Section V highlights the non-participatory bias in MT, and in the recent Science and Technology (S&T) policy formulation process in India. This is followed in Section VI by a brief discussion of how the S&T policies can be alternatively conceptualised in society-based perspectives. The paper concludes in Section VII with some suggestions about integrative strategic approaches in a framework of regional co-operation.

II Modern Technologies

To begin with, we confine our understanding of MT to applications of basic scientific knowledge to economically and socially viable and useful purposes over say the last two-three centuries. The development of basic scientific knowledge, especially in Europe, precedes the development of MT by at least 500 years, if not longer. Historically, the increase in the development and spread of MT during the recent centuries has been associated with the advent of the Industrial Revolution in northern Europe in the 18th and 19th centuries, particularly in England and Germany, followed by the development of the US in the 19th and 20th centuries.

This historical period was characterised in the West by the gradual displacement of the monarchic-oligarchic-feudalistic regimes with more democratic ones. This also resulted in relative decline of the historically and traditionally dominant feudal economic classes and the rise of the new market and technology driven economic and industrial elites, particularly in northern Europe. The political and economic liberalisation was aided by the gradual philosophical shift from Catholicism based “other-worldly” world views to Protestantism and Calvinism based “this-worldly” ones, and the advent of the “Age of Reason and Enlightenment.” The latter drew strength from the spread of scientific ideas, and increasing democratisation, commercialisation and marketisation of economies. These political, philosophical and economic developments, from our point of view, accelerated the spread of increasingly commercialised, mechanised, non-renewable resource and energy intensive and labour displacing MT.

The new profit-seeking elites, with their increasing economic, organisational and modern technological strengths, overwhelmed the sustainability of Traditional and Indigenous Technologies (more on TIT later) not only within Europe but also in the increasingly accessible regions outside Europe which were colonised by their governments. Thus, the access to material and labour inputs required for MT based production and markets for the outputs expanded globally, leaving TIT-based production and consumption to local fragmented input and output markets.

Who are the drivers and beneficiaries of MT? To begin with, they are the consumers of MT based products. As rational consumers they welcome MT, which provides standardised, cheaper, more convenient, accessible and even often qualitatively
better products and services. MT also offers more choices than what TIT can. Given these basic consumer preferences and tastes, buttressed by organisationally created demands for increasing wants rather than needs, the private and public suppliers of such MT-based products and services attempt to maximise their personal, organisational and public benefits, within the limitations of input and output short-term and long term market dynamics, and policy and geo-political constraints. They include private and public, national and multi-national manufacturing, service and agricultural organisations, financial institutions, S & T and R & D institutions, and policy-making bodies, with varying degrees of influence across sectors, countries and regions.

III Traditional and Indigenous Technology

Traditional and Indigenous Technology (TIT) evolved over the centuries mostly through local experiential and contextual learning and undocumented transfer of relevant knowledge, technology and skills across generations through families and informal craft communities and guilds. TIT based production involves great deal of manual work. There were (are) no scientific theories on the basis of which TIT developed. Pre-modern science was (and is) too esoteric and far-removed from the common masses to influence the development and practice of TIT. During the pre-industrial period – say preceding the 19th century – TIT facilitated the production of all the goods and services required not only by the feudal / monarchical ruling elites and middle classes but also by the common people all over the world. A great deal of outputs facilitated by TIT were for consumption by self / family or geographically accessible neighbouring communities. One would surmise that TIT-based activities were so rooted in local economic, social and environmental contexts that changes in the larger systems of philosophy, polity and economy could have had no positive or negative impact on them. They were locally sustainable economically, ecologically and socially. This was because they were based on relatively limited local demands, and on more naturally renewable and locally available inputs.

With the advent of MT, however, the challenges to TIT-based production increased in many respects. TIT could not match the low-cost mass-production for mass-consumption engendered by MT, catering increasingly to the demands of the rising middle income classes across countries and regions. Given this structural shift in demand for products, and consequently for labour, from TIT to MT, the younger generation of the mostly rural TIT based producers were (and are) increasingly forced to seek livelihood in urban factory based sectors (the “push factor”). But they were (and are) also attracted by the lure of urban life and mechanised time-bound work in MT-based factories, and better economic and social infrastructure in urban areas (the “pull factor”). The family, craft-guild and other networks for continuing and sustaining TIT consequently weakened. In an atmosphere dominated by MT-based global and national producers and their supporters and consumers, many governments and civil society organisations (e.g., producers’ co-operatives) have over time recognised that TIT-based production needs to be sustained and encouraged for economic, geographical as well as cultural reasons, including the promotion of decentralised and dispersed employment and input provision, and preservation and promotion of local handicraft and culture-specific products, skills and trades.
IV Characterististics of MT-based and TIT-based Products

We now attempt to broadly come up with distinguishable characteristics of TIT and MT based products and processes in terms of their psychological, sociological and political-economic implications. It goes without saying and further elaboration that there is no sharp conceptual or empirical line one can draw between MT and TIT products. But it is possible to conceptualise the differences by selecting products or processes placed closer to the extreme ends of the TIT- MT continuum.

To help more sharply delineate the characteristics and ambiance of TIT and MT, we can visualise TIT-based local products such as home-made or tailor-made clothing, pottery and utensils, ethnic food items, home accessories and furnishings, etc. mostly for self or local consumption, at one end of the continuum, and MT-based mass-produced products such as factory-made clothing, utensils, ceramics and pottery, personal accessories, packaged/pre-cooked “microwaveable” meals for mass consumption, at the other.

Keeping these examples of TIT-based and MT-based products, we attempt in the table below to more sharply distinguish between the respective characteristics of the products, production processes, marketing and demand, and broader ambience of these two sectors. The table highlights the distinguishing characteristics as bought out by Waqif, Asim (2010), who had extensive on-site discussions with some 20 artisans and their families in Italy on TIT and MT based products in local contexts, and by Ritzer (2004), who conceptualises MT-based products as approaching “nothing” and TIT based products as approaching “something” in global consumption markets and frameworks.

Table 1: Comparison of TIT and MT based Products.
|   | **TIT based Products**  
(e.g. A home-made or chef cooked meal) | **MT based Products**  
(e.g. A factory packaged pre-cooked meal) |
|---|---|
| **A**  
Product | Product |
| Unique, peculiar, distinctive, unpredictable, heterogeneous, not easily replicable, unbranded | Standardised, uniform, homogeneous, predictable, replicable, branded |
| Locally produced, distributed and consumed | Mass-produced, mass-distributed and mass-consumed across national/global markets |
| Locally random designs, content and quality | Centrally conceived and standardised designs, content and quality |
| **B**  
Production Process | Production Process |
| Involves locally skilled manual work for the whole product - labour and local/natural resource intensive | Involves globally semi-skilled labour with mechanisation/automation for product components - global capital, technology, transport and commercial energy intensive |
| Rising (opportunity) costs of local skilled labour | Increasing global access to cheaper and globally standardised semi-skilled labour |
| Uses mostly locally produced hand-made renewable natural material inputs | Uses mostly globally produced, machine-made synthetised material inputs, derived mostly from non-renewable resources |
| Local producer initiated, directed and monitored process which is time and location-specific | Centrally-organisationally initiated, directed and monitored process which is time-less and place-less |
| Local specialised skills transferred informally through family, craft communities, guilds etc., and experience-based learning over generations | Relatively universal standardised skills transferred formally through organisational/corporate training and orientation programmes. |
| **C**  
Product Marketing and Demand | Product Marketing and Demand |
| Producer and consumer in closer proximity, based on more personal human contacts and local relationships | Producer and worker far removed from consumer in time and space, impersonal centrally-organisationally programmed contacts, salesmanship and relationships |
| Own shop/ workshop and locally linked establishments as marketing outlets, producers as primary involved, knowledgeable sales-persons | Centrally organised malls, supermarkets, department stores, TV and internat sales etc relatively uninvolved, non-knowledgeable sales persons |
| Markets increasingly unfavourable due to stiff competition from MT-based products, changing consumer preferences and tastes, higher costs, and limited accessibility | Markets increasingly favourable due to changing consumer preferences and tastes, lower costs, and relatively unlimited expanding accessibility. |
| Mostly to meet demands of family, local community, elitist demands | Almost entirely to meet increasing global mass (manufactured) demands |
| The imperative to produce is the livelihood of the producer through local demand | The imperative to produce is profits through global (manufactured) demands |
Table 1(cont.): Comparison of TIT and MT based Products (cont.).

<table>
<thead>
<tr>
<th>D Ambience</th>
<th>TIT based Products (e.g. A home-made or chef cooked meal)</th>
<th>MT based Products (e.g. A factory packaged pre-cooked meal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambience</td>
<td>National and global technological and policy-legal frameworks increasingly unfavourable - producers too small and unorganised to have effective lobbies</td>
<td>Increasingly favourable technological and policy-legal frameworks - large and organised producers with effective lobbies</td>
</tr>
<tr>
<td>Ambience</td>
<td>Due to limited market access, inherent producer bias in favour of thrift sustainability, balance between needs/wants, and availability of natural resources</td>
<td>Due to expanding market access and competition, inherent bias in favour of profitability at all cost, and increasingly unsustainable imbalance between society's needs/wants and availability of natural resources</td>
</tr>
<tr>
<td>Ambience</td>
<td>Much greater scope for creativity, ownership, passionate involvement, self satisfaction, innovation in production for the producer-worker, apart from monetary benefits</td>
<td>Centrally-organisationally programmed and scripted production, with little or no room for individual creativity, innovation and self-satisfaction for the producer-worker except from wages, perks and profits</td>
</tr>
<tr>
<td>Ambience</td>
<td>Self-programmed production cycles provide greater scope for self time management, time for the family etc.</td>
<td>Organisationally programmed time-management at work place and at home</td>
</tr>
</tbody>
</table>

We can broadly conclude from the table that there are identifiable psychological, social, economic and political-economic distinctions between TIT and MT-based products, production processes, marketing approaches and micro and macro level ambience. These distinctions have implications for psycho-social and economic life-styles and well-being of the respective producers, workers and consumers, as brought out in the table. In the next section we highlight selected aspects of science and technology policy formulation processes in India which have broad political-economic and welfare implications for MT and TIT-based sectors.

V Democracy and Science Policy in India

Prasad (2008) has elicited the broad non-democratic contours of science policy (SP) formulation in India. According to him SP in India is “by and for” the scientists. The SP formulation process in the government largely bypasses any notions of democratic public engagement and debate, critical thinking, and broad-based knowledge dialogues and learning alliances. It is heavily biased in favour of MT in atomic energy, space, and defence, which together were allocated 78 per cent of Rs. 25,500 crores of the 10th Plan S & T budget, while technology development for the rural poor received only 0.23 per cent (ibid., pp 92-93). Furthermore, it ignores the developmental aspirations of the economically poor but traditional knowledge- and technology- rich and practically capable masses. Relying heavily on MT, Indian SP pays scant attention to diverse and alternative traditional knowledge and technological practices especially in the areas of agriculture, textiles and health. This is mostly because – as brought out in the earlier table – producers and users of TIT based products are unorganised and scattered and
economically much less powerful than those of MT based products. (The primary producer and user of space, atomic energy and defence is the government itself.)

While MT-driven innovations do result in development of new products, they are disproportionately concentrated in management of operations, sales and marketing. Only in the case of handloom-khadi sector has the people's participation resulted in more equitable co-production of knowledge and technology, and inter-penetration of TIT and MT. But generally, the consideration of TIT-MT relationship and inter-dependence, and their cultural, social and economic diversities and ramifications have been neglected, due to the obtaining national and global power dynamics. Though the National Knowledge Commission has recently argued for a much more pluralistic and inclusive approach to SP formulation, the singular MT-based mindsets - a legacy of the Nehru era – continue to largely promote MT and neglect TIT.

The next section addresses some conceptual approaches to help integrate MT and TIT in societal perspectives.

VI Alternate Perspectives on Science and Society

Waqif, Arif (1984) observes that organised natural science ideally relies on repeatability, confirmability, uniqueness and objectivity (value-freeness) of scientific approaches and solutions. But in reality, there are often differing or even conflicting scientific views, and scientists' pursuits and values are not independent of their personal views, education and training, career aspirations, institutional settings in which they work, and science sponsors' political-economic agendas – witness the debates on global warming and climate change, or nuclear energy, for instance. Thus, modern science and technology can be viewed as a political-economic commodity or public good, depending on who produces MT, for whom, who gains, who loses, and their relative bargaining powers, as partly brought out in the previous section.

At the same time, modern science's bias in favour of universalism, determinism, centralism and urban elitism results in a dominant focus on economic and material needs, to the neglect of psychological, cultural, social and even spiritual needs of producers, workers and consumers of MT. Predominantly manual skill-based, self-contained, self-directed, self-satisfying and relatively ecologically non-violent work based on TIT gets replaced by mechanised, centrally-directed, fractionalised, co-ordinative and integrative work based on MT. Uniqueness, particularity and substantiveness of locally produced TIT based products give way to uniformity, standardisation and soullessness of mass-produced MT based products – along Ritzer's continuum of “something” and “nothing” - and relatively monolithic life-styles and consumption patterns across the globe.

But, as per Jacques Ellul's observation quoted by Waqif: “By sheer numerical proliferation and velocity, (modern) technological means of production (and consumption) unavoidably surpass man's relatively unchanging biological, emotional and spiritual capabilities” (ibid, p 226). Aided by their political economy, society becomes increasingly controlled by the MT establishments. But, as per E.J. Mishan's observation quoted by Waqif: “Man should adjust the technological environment to his natural needs and capacities. Technological progress may appear to be inevitable and unstoppable, but man should consider the possibility that the needs of men and needs of commerce and
VII Some Suggestions for Integration of TIT and MT

Hence, there is a conceptual and strategic need to facilitate the inter-penetration and integration of TIT and MT, and to balance their social benefits and costs. Such facilitation has to go beyond what Ritzer has called “globalisation” (op cit, pp 78-79 and chap 5) – that is, beyond the corporate driven vegetable burgers in fast food chains, or herbal tooth pastes, or packaged ethnic foods.

Creation of technological, economic and social space for TIT based products needs to be considered through increasing and effective social marketing and awareness generation among producers and consumers, provision of affordable inputs and infrastructure, market access, and promotion of participatory and decentralised technology and skill development. Though a lot of lip service is paid to these aspects by the political and administrative establishments, resource allocation leaves much to be desired. Relentless expansion of global and national producers and retail chains needs to be checked to provide space for local producers and retailers. Inter-penetration of global MT and local TIT needs to be encouraged, e.g. in management of agricultural pests through integrated (organic and chemical) pest management, partial non-commercial energy intensive mechanisation of household production, post- harvest crop processing by farmers, etc. The possibility of imparting skills for TIT through the industrial and vocational training institutes is also worth considering. Furthermore, modules on TIT could be introduced in science and technology and social science and management curricula in colleges and universities, and even in executive training programmes.

At the intra-regional and regional co-operation levels, there is a great deal of scope for promoting cross-border experience-sharing and technology and skill development and transfer in TIT. These would entail suitable support from sectoral, national and regional organisations (such as SAARC). The regional economic cooperation frameworks (such as the South Asian Free Trade Agreement) could also incorporate specific provisions for regional trade and investment and market development in TIT. Sub-national, national and regional (SAARC) chambers of commerce and industry and export promotion organisations could have special cells to promote trade and investment in TIT, especially in household, micro and small enterprises. All these efforts would need to be actively supported by civil society and labour organisations and networks at local, national and regional levels.

The approaches to sustain and promote TIT and TIT-MT inter-penetration for economic and socio-cultural reasons have to go beyond pious policy intentions and statements. They need to be translated into effective and reasonably resourced sector-specific participatory and organisationally coordinated programmes and projects at local, national and regional levels.
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Dr. Mohsin U. Khan
Problems of technology transfer from laboratory to industry and policy issues in India

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Abstract: This paper attempts to review the development of indigenous technology in India over the last forty years. It identifies the problems of technology transfer that Indian national laboratories are facing. Indian technology does not have strong linkages with the industry with the result, limited utilization of research. India could not catch up advances abroad because of so much protection to industry. On the other hand situation become worst after sudden liberalization during 1991 when indigenous technology had to compete with the mighty multinationals. Some of the industries vanished from the market due to tough competition. India should drastically change her R&D priorities to face the liberalization. India should concentrate on areas where it has build up capabilities and excellence over the years, like software industry in computers. Secondly India should establish strong linkages with the industry to make suitable value additions in the imported technologies.

Keywords: Technology transfer; Technology policy; Liberalization; Multinationals; Indian industry; Indian technology policy; R&D Management; Indigenous technology; International technology transfer and Foreign investment.

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1. Introduction

Achievement of self-reliance has been one of the declared goals of India’s development plans. Since technology is basic to any process development, the self-reliance would not be complete without technological independence. This recognition has led to evolution of policies geared to strengthen local technological capability to ultimately achieve technological self-reliance [1,7]. The industrial trade and fiscal policies pursued over the past four decades have contained policy instruments directly or
indirectly concerning technological development. Besides these, the Scientific Policy Resolution, 1958[46], laying down the framework for development of infrastructure for technological development. The Technology Policy Statement of 1983 [47], retreating the goal of technological self-reliance and providing guidelines for the policy instruments enunciated.

The *modus operandi* of the technology policy thus evolved has been two pronged as in the case of industrial development. They have sought to provide to local technology or skill from the imported ones on one hand. On the other hand, the local generation of technology accelerated directly and indirectly. Immense technological capability generated as a result of these policies. That brought the country near the technological self-reliance in a number of industries. India exported a wide range of technologies and projects to other developing countries. There are some other areas, where technological self-reliance is nowhere in sight and the technological gap widened over the years. Micro-electronics area is such an example [11].

The paper discusses the theoretical framework of technology transfer; aims of the technology policy of India from 1960s onwards; problems of technology transfer from laboratory to industry; impact of liberalization on technological change in the Indian industry.

2. Technology transfer:

Technology has been viewed as the key to the development of the western world. Developing countries are increasingly becoming aware of technology in the process of economic growth. As Grubber and Marquis [14] pointed out the recognition of the needs for a better understanding of transfer of technology is based on the transition from a private to government sponsorship of research and on the increase in the proportion of national income devoted to R&D activities. Both developed and developing nations have increasingly oriented their science and technology policy towards economic goals [29].

Technology transfer can be viewed as generalized process of information transfer between science, technology and production of scientific ideas. Brooks [5] made a distinction between two types of technology transfer: Vertical and horizontal.

Vertical transfer refers to the technology transfer of technology along the line from the more general to more specific. In particular it is the process by which new scientific knowledge is incorporated into technology, and by which a state of art becomes embodied in a system and by which the confluence of several different and apparently unrelated technologies lead to a new technology. Horizontal transfer occurs through adaptation of a technology from one application to another, possibly wholly unrelated to the first.

Analysis of this two types of technology transfer would show that horizontal transfer generally involves an inter-organizational process where vertical transfer generally involves intra-organisational process. The aspects of horizontal transfer proposed by Doctors [12] and Bar-Zakey [3] is the process by which the information generated in one institutional setting (e.g. health care). These definitions of technology transfer implicitly assumes technology as a transmissible seminal idea. As Burns [6]
pointed out, the basic assumption of technology transfer, as an assemblage of pieces of technology transfer which can be extracted or expelled from one sector of organized creativity and transposed to another to produce different outputs, is implied in the space age jargons like spin-off, fallout, etc.

Technology transfer comprises a sequence of following phases: Idea generation, invention, innovation and diffusion. Each phase has an environment which influences its operation as well as its output. However, transfer may initiate from any of the phases depending upon the status of technology to be transferred.

A lot of literature on technology transfer is available, which is largely concerned with the last two phases, innovation and diffusion. The core of this literature deals with stimuli and barriers to the success of an innovation and to its diffusion. More precisely in specific studies of production technology a number of key factors have identified which have either stimulated or stifled the process of technology transfer.

The conclusion of the few significant studies summarized below. Project SAPPHO [33], which was carried out at Science Policy Research Unit at Sussex, is a major attempt to identify and evaluate the factors that distinguish innovations which have achieved commercial success from those which have not. This study is based on the assumption that innovation is a complex sequence of events, involving scientific research and technological development, management, production and marketing. Therefore single factor interpretations are less than satisfactory and allowances must be made for multi-factor explanations. In all 29 pairs of failed innovations alongside parallel success were studied, 17 in chemical industries and 12 in instruments industries. The result indicates consistent patterns of difference between success and failure in innovation which can be summarized in following five statements.

Marketing:
Successful innovators pay much more attention to marketing. Failure is characterized by neglect of market research, publicity and users education and failures to anticipate customer’s problems

User needs:
Successful innovators have a much better understanding of user needs. Conversely the neglect of user needs or failure to interpret such needs in the R&D work leads to failure in innovation.

R&D strength:
Successful innovators perform their development work more efficiently than failures, but not necessarily more quickly. They eliminate technical defects from the product or process before they launch it.

Communication:
Successful innovators make more effective use of outside technology and scientific device even though they perform more of the work in-house.
Management strength:

The responsible individuals in the successful attempts are usually more senior and have greater authority than their counterparts who fail. The greater power is reflected in satisfactory controlling the project, establishing effective internal and external communications networks and integrating the project into overall company strategies.

In another study Schwartz [34] concludes that innovation whether based on internal ideas or transferred technology is a manageable process. It is bad decision rather than technical or informational deficiencies that influence the success of innovative efforts. According to him, the innovative firms must have innovative strategies.

The following four requirements are essential:

Technical and marketing intelligence must quickly come to the attention of those who need it for proposal and for decision making. Proposals that do not have the benefits of the latest ideas available are likely to be inferior.

There must exist in the firm ethos of risk taking:

There must be high order coordination of the activities of specialists to facilitate exchange of ideas in all related aspects.

Recognizing the constant pressure of urgent operational problems, there is a special need to focus the attention of senior manager on such strategic matters as innovation.

There is a broad agreement among the various studies relating to factors promoting successful innovations. Rothwell [32] mentions the following factors:

- Good communication and effective collaboration, both inter and intra-firm.
- Innovation seen as corporate wide task.
- Use of careful planning and management techniques.
- Organic and open management style with both commitment and enthusiasm for each project.
- Response to recognition of user needs.
- Good after sales service and user education.
- Presence of key individuals.
- Importance of “small step” advance.
- Influence of government assistance.

Globe, Levy and Schwartz [13] concluded in the follow up of “Traces” study that 69 percent of decisive events in innovation were characterized by “recognition of need” though this was over weighted by 87 percent attributable to recognition of technical opportunity.

There are special characteristics of government laboratories and they face more problems and difficulties due to hierarchical complexities, human relations and types of environment required for transferring know-how. Some of the outstanding barriers
experienced in the government agencies in the process of technology transfer have been mentioned by Doctors [12]. According to him possible barriers are:

- Insufficient mission orientation of technical personnel in most of the agencies.
- Institutional barriers to information flow.
- Low value placed on the transfer function by scientific and technological personnel engaged in federally sponsored R&D.
- Vertical nature of institutions for transfer.
- Poor and antiquated methods of information retrieval and evaluation.
- Poor understanding of the process and power structure of the agencies themselves.

The mechanism which triggers the innovation has been examined by several researchers. Utterback [45] has noted from a review of studies on technology transfer innovation by different authors that 60-80 per cent of important innovations in different fields have been in response to market demands and needs (need pull) while the remainder 20-40 per cent have originated from scientific/technological advances or opportunities (technology push)

### Innovations stimulated by market needs and technological opportunities

<table>
<thead>
<tr>
<th>Author</th>
<th>Proportion of innovations from needs of market production or government</th>
<th>Proportion of new technical opportunities (%)</th>
<th>Sample size</th>
</tr>
</thead>
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<tr>
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<td>90</td>
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Baker and Rubenstien [2] have postulated that two events are necessary precursors for the generation of an idea of innovation, 1) need event that is recognition of the need, problem or opportunity which is perceived to be relevant to organizational
objectives; and 2) means event, that is recognition of a means or techniques by which to satisfy the needs, solve the problems or capitalize on the opportunity. It is not essential that the need event should occur prior to the means event, but the occurrence of both the events is essential for idea generation. However, from a survey of innovations studied by them they found that “need event” usually occurs prior to the “means event.”

3. Aims of technology import policy of India from 1960s onwards.

Indian technology policy is determined by the self-reliance objectives of developmental planning. The basic approach has been an inward looking one, which in relation to technology transfer has meant the adoption of policy measures to prevent foreign ownership, to control productive activities, to unbundle technology package, to internalize skills and institutional structures, to acquire self confidence to meet its own needs increasingly and then to look outwards and extend co-operation in technology matters to other third world countries [36].

In pursuit of this approach, administrative guidelines and procedures have been used for regulating transfer of technology on a selective basis. Every permissible import of technology is screened and approved by considering its mechanism and terms of the transfer and its impact on local technological development and balance of payments.

Indian policy concerning technology transfer has evolved through a number of stages. In the first stage, until 1968, foreign collaboration agreements were approved through administrative procedures based primarily on foreign exchange considerations. More detailed procedures for screening collaborative agreements including technical evaluation and registering were established in the second stage between 1969 and 1978. In the third stage initiated in 1978, a more liberal policy has been adopted. Out of more than 6,500 collaborations approved between 1950 and 1980, around 84 per cent of cases did not entail any foreign ownership participation. Technological collaboration (licensing) agreement has thus been the major formal mechanism used for technology transfer [36].

Simultaneously with a policy of selective imports of technology, Indian technology policy has been aimed at stimulating indigenous technologies/developments. The policy measures used can be classified as either compulsive or incentive. Examples of the first type are; a) forbidding import of technology available locally without much time lag, b) stipulation of target oriented indigenisation of production, c) strict scrutiny of applications for renewals of collaboration agreements, d) tax rebates and other incentives for implant R&D and e) increased state outlays on strengthening indigenous science and technology (S&T) systems.

The compulsive instruments must have exerted environmental pressures on the firms towards moving rapidly on technology-independence continuum by assimilation and adaptation of imported design and manufacturing processes. Ability to learn and assimilate technology must have been raised by the government’s initiatives on subsidizing and strengthening technological infrastructure over time [28].

At the same time the learning process would be constrained if excessively the restrictive conditions were imposed on the use of imported technology by the government of the host country. Detailed information about restrictive clauses in agreements
approved by the government of India are not available. The ones approved upon the sixties invariably had such limiting clauses.

### 3.1 Promotion of indigenous technology

In order to encourage the indigenously developed know-how and promote in-house R&D various policy measures have been adopted by the government. Mainly two types of policies affect R&D activity and its commercial exploitation. Firstly, those measures which are offered by the government in order to promote in-house R&D activity and the incentives offered by National Development Research Corporation (NRDC) [48] to firms and entrepreneurs to purchase locally developed technologies. Second, protection offered to indigenous know-how against foreign know-how by the licensing mechanisms [10].

The incentives offered to in-house R&D were quite wide. Complete income tax exemption was given to expenses incurred by a firm on R&D activities. Weighted deduction in taxes was also offered to expenses incurred by a private firm which sponsored research in a national laboratory of CSIR [49] or a research association or an institution approved by the “prescribed authority” of the government in the field. A forty per cent deduction in computation of income and tax thereon also made on income from royalty, technical fees ...etc. If the firm secures this income by providing know-how to foreign firm outside the country, the entire amount deductible from income tax. A highly liberal policy of import of equipment, instruments and raw materials and spare parts needed for doing research by the research organizations recognized by the prescribed authority also offered. In 1976 this policy was further liberalized and private firms registered and recognized by the Department of Science and Technology (DST) [50] as having definite research schemes were allowed to import equipment, etc. needed for R&D work up to a value of Rs 100,000 without any import license. There were about 348 private firms and 20 public sector firms in 1976 which were recognized by DST as having facilities on in-house R&D expenses claimed by these firms, as R&D expenses in 1976 were around Rs 500 million [9].

NRDC, the organization mainly responsible for developing and marketing processes developed at CSIR laboratories, also offers a number of services for purchase of know-how. Since the development of pilot plant prototype, demonstration plant, etc. add substantially to the total cost of developing the new technology and may constitute a crucial element in entrepreneurial decision to switch over to new technology, NRDC shares 50 percent of the cost incurred in these steps. Such a decision must be endorsed by the DST. Tax concessions were also offered to the entrepreneur on whatever expenses he incurred in these steps. The NRDC also offers a guarantee for performance of the new technology on a commercial scale and also helps with other services like obtaining imported equipment, materials and components and sometimes obtaining financial loans.

Among the indirect measures of protection offered to indigenous know-how, there were following types of regulation mechanisms: Industrial licensing, import and export stipulations differential laws of corporate taxation and control of foreign collaboration [35,24,23]. The general guidelines for control of foreign know-how and capital are

The emphasis and the focus of the control mechanism has shifted in different documents and these shifts have been interpreted differently in the studies made on the subject. Without going into the details of changing nature of the control mechanism its salient features are presented here.

Since the beginning the main thrust of the control of know-how on investment had been through the licensing device. All applications for foreign collaboration, and incorporation of foreign capital had to be submitted to the government and approved by the (inter-ministerial committee) Foreign Agreement Committee. In order to regulate the direction of agreement of technological change, the Foreign Investment Board of the Ministry of Industry had identified areas of industrial activity where foreign participation in know-how or capital or both are not needed. The Board also identified areas in which the country could be considered relatively self-sufficient and no new technology was allowed to be imported. The government’s licensing committee, however, had never interfered between the foreign collaborator and the local firm as a bargainer. It simply had the power of approving or rejecting the terms of the proposed collaboration. Such a mechanism had obviously its own limitations [4].

But the main success of this device, it has been noted, that the government had been able to successfully cut down the foreign costs of collaboration by regulating the terms of payments and royalties [25].

Government has been successful in some cases in obtaining a progressive dilution of the foreign share holding, in deleting clauses banning exports, in preventing the use of brand names and in insisting on the involvement of local design consultants. The government, in order to protect know-how had also put the representative of the CSIR in the licensing committee that sanctions the applications for collaboration. Differential laws of corporate taxation have also been stipulated for Indian and foreign firms as a measure of control of foreign know-how [8].

3.2 Problems with regard to technology transfer.

Problems of technology transfer can be discussed at two levels. First, at laboratory level, right from the inception of the R&D project to its completion. Secondly, when it is ready for commercial exploitation. Technology transfer is done through various transfer institutions like NRDC and TUD (Technology Utilization Division) [51]. Before that an assessment of the market demand and competition with the foreign technology is undertaken.

First, let us discuss the problems of technology transfer at laboratory level. In a few CSIR laboratories efforts have been made to undertake studies on cost-benefit analysis, techno-economic feasibility, market demand and assessment of social needs for specific research programs [52]. The needs of the research and development are generally perceived by scientists on the basis of their knowledge in the area of research. Scientists are not sure about the economic feasibility of the inventions to be developed before the research is performed and actual bench scale results are obtained. Further, scientists are mostly concerned with the publication of the results of their research rather than
pursuing the planning of R&D activities beyond bench scale results for opening up opportunities for commercialization [27].

Moreover, a research project in which the whole range of technology transfer consists of detailed planning and complexity of management which the scientists are reluctant to undertake. Some of them believe that planning is antithetical to scientific research itself. Furthermore, applied research is multi-disciplinary in nature requiring co-operation of a number of scientists and technicians.

In the operation of the project, the boundaries between research divisions are rarely transcended, inter-divisional co-operation is accepted in principle by the scientists yet it has not been achieved in practice [53]. The scientists fears that a research project, involving high expenditure will not find favor from the authority. Finally the scientists do not have the business approach, they have not been trained for it. This is evident from the research results of the laboratories presented by them. These economic assessments have been rudimentary. Cost-benefit analysis has been worked out by manipulating figures which are favorable to the research results. The investment figure for commercializing the results are underestimated while profits from production are overestimated [37].

This raises the expectations of the entrepreneurs to obtain high rate of return on their investment in the adoption of the indigenous know-how. It has been noticed that during the course of transfer of know-how, it was realized by many entrepreneurs that actual investment figures for setting up production were much higher than those contained in the estimates provided by the laboratory. There is little to blame the scientists for this. In the absence of availability of expert knowledge of the economic impact of indigenous research, application of techno-economic analysis to research projects and their results must be improved.

Interaction between laboratory and industry helps in the identification and selection of research projects which are connected with the problems of the industry. The research results obtained from such project have good chances of being commercialized. Impeded or intermittent communication kept the research results on the fringe of failure.

Technology transfer from R&D institutions to industry seems to be more complex and difficult in developing countries. In a developed country the industry has the necessary capabilities to assess the work done in R&D laboratories without much or any assistance from outside. The developed countries firms can conduct their own market surveys with regard to feasibility of technology in hand, organize the design and construction of the plant, training of the personnel, manufacture and ultimate sale of the product. This is not so in a developing country where the entrepreneur requires assistance from the stage of selection of a process or product until he sells it. He needs assistance for the preparation of the feasibility report for obtaining loans from financial institutions, design of the equipment, erection start up trouble shooting, training of personnel, maintenance and ultimate sale of the product. Often he needs special assistance, tax rebates to aid the sale of his product [37].

The entrepreneurs want to have a technology with guaranteed performance. One of the best means of insuring transference of technology from indigenous research laboratories to industry is offering a) prototype of the product b) trying out of the processes/products on pilot plant scale and according to certain laid down specifications
initially. It may be emphasized here that relatively more attention needs to be given to
development work on pilot plants, prototypes demonstration units, making available
feasibility report, cost estimates and market surveys.

Pilot plant work may even costs ten times more than the cost of the work done at
the laboratory stage, but any hesitation or reservation in incurring this expenditure at the
pilot plant/bench scale and demonstration stage could lead to severe-bottlenecks, even if
the technology passed to genuine entrepreneur its commercial viability may eventually
die. The work at the pilot plant level goes a long way to check premature or exaggerated
claims of the R&D scientists and thus avoids later failures of the technology [30].

There are problems in setting up pilot plants due to a) non-availability of finances,
b) the time required to establish the plant is at least one year or sometimes more. By the
time the pilot plant is ready the technology used is overtaken by new technologies
developed somewhere else. Consequently, as much as possible, the R&D work should be
completed at the laboratory stage. The availability of the feasibility reports, cost estimates
and market surveys will fill the initial gaps and help create confidence in the entrepreneur
to convert the industrial research into a commercially viable unit.

The feasibility report prompts the prospective entrepreneur to know about the
worthiness of the R&D work. It will determine whether or not the market exist for
indigenous technology, raw materials, labor with necessary technical skill are available,
infrastucture vital to the project is at hand. The entrepreneur will also know the estimates
of overall costs of plant and equipment etc. Most important is the fact that from the
feasibility report the prospective entrepreneur is able to determine the expected income
from the indigenous technology that will help workout the profit margin. R&D
laboratories can go a step further help the industry/entrepreneur by offering plant on turn-
key basis with adequate performance guaranteed wherein the R&D personnel could be
actively associated with the production operation even after commissioning the plant.

It is important to associate engineers (mechanical, electrical, electronics as the
case may be) from industry with the R&D investigations at the early stages in the
laboratories, so that difficulties of designing the plant, machinery and equipment,
installation etc., could be avoided at the time of technology transfer. The indigenous
technology developed in the laboratories will certainly be successful if the engineers from
industry help scientists in the design of the plant and machinery in improving the quality
of the product in response to market changes [30].

Another problem of the technology transfer is the lack of confidence in the minds
of Indian entrepreneurs in indigenous know-how. There is competition between
indigenous technology in its infancy and foreign technology proved for several decades
under well known trade marks. Therefore, it is necessary to somehow instill the
confidence in the Indian entrepreneurs about indigenous technology.

Technology transfer requires a long chain of activities such as assessment of
market demand, availability of finance, training of personnel...etc. Due consideration had
not been given to provide a complete package of technology transfer to the adopters.
Sometimes a technology is not utilized because the adopter is not able to obtain capital
goods and raw materials licenses, or is unable to arrange foreign exchange etc [54].
4. Impact of liberalization on technological change in India from 1991 onwards.

A major objective of the economic reforms program initiated in India in 1991 is to make the country more attractive to the transnational corporations (TNCs), and induce them to invest more money in India. A basic premise of the new economic policy is that a larger inflow of foreign direct investment (FDI) is *per se* good for the country. In this section we are mainly concerned primarily with the question whether unregulated entry and expansion of TNCs is necessary for technological change in the country.

4.1 *Advantages for TNCs*

The policy changes since 1991 favorably influence the operations of the TNCs as discussed below:

(a) The restrictions on the spheres of operations of the TNCs have been drastically reduced. In the past new FDI had to be justified having regard to factors such as priority of industries, nature of technology, degree of exports etc. [15,16,17] The government used to announce illustrative list of industries where no foreign collaboration is considered necessary. These restrictions have been abolished. Now all the industries are open for entry of foreign investors, though for those industries not mentioned in Appendix 1, government permission is still necessary. Moreover, the policy of automatic approval in Appendix 1 industries makes the policy transparent and is expected to reduce the bureaucratic impediments associated with discretionary policies of the past.

The sphere of operation of the existing foreign companies will be much larger due to the following reasons:

1. **FERA companies are no longer required to restrict their activities to Appendix 1 industries or to predominantly export oriented activities.**

2. **The industrial policy of 1991 has drastically reduced the number of industries reserved for the public sector.** The list has been further reduced in March 1993. Now only six industries viz., defense products, atomic energy, coal and lignite, mineral oils, railway transport and minerals specified in the schedule to Atomic Energy order 1953 are reserved for the public sector [20]. Thus the TNCs (as well as the Indian private companies) are now permitted to invest in iron and steel, mining of iron ore, heavy electrical plant, telephone and telephone cables generation and distribution of electricity etc., which were previously reserved for the public sector.

3. **The protection provided to small scale firms being reduced.** The government has decided to slash the list of items reserved for the small scale sector. Garments, e.g. has already been de-reserved. The large firms are now allowed to produce the items reserved for the small scale sector provided they export 75 per cent of the output it has been reported that the government is planning to induce the export obligation to 50 per cent The small scale sector also used to be protected indirectly under the policy of excise tax exemption. Within the withdrawal of such exemptions in the Union Budget of 1994-95, the advantages enjoyed by the small manufacturers will be eliminated in a large number of industries, e.g. shoes, bar soaps etc..

4. **The industrial policy of 1991 has abolished industrial license except for a short list of industries related to security and strategic concerns, hazardous chemicals,
few items of elitist consumption, etc. Licensing has been further liberalized with motor cars, white goods (refrigerators, washing machines, microwave ovens, air-conditioning etc.) and almost all the bulk drugs and their formulations taken off the list of industries for which licensing is still required. [18,20,21]

5. The restrictions imposed by Monopolies and Restrictive Trade Practices (MRTP) Act large firms expansion merger amalgamation and take-over etc. have been abolished. Such enlargement of areas of operations of existing firms also acts as an incentive for new firms. A new TNC is required to participate in the Appendix industries to be eligible for automatic 51 per cent foreign equity, but once the company is set up, the TNC can expand and diversify as explained above.

(b) Under the previous policy the foreign companies were debarred from using their brand names fully unless the sales were for essential drugs and pesticides. It is believed that the free use of brand names now would enhance the market power and hence the growth of TNCs in India.

(c) Left to themselves the TNCs naturally would decide the nature of their operation in a particular country with reference to their objectives of global profit maximization. The trade restrictions on the TNCs in the form of a local content or export performance requirements as we had in India to some extent, often conflicted with such global objectives. Now the TNCs in India are no longer required to export in order to enter, grow or have higher foreign equity. Similarly with the abolition of the Phased Manufacturing Program (PMP) the TNCs are now free to decide whether they will use imported or local material.

(d) Another advantage claimed for the TNCs is the increase in the permissible extent of foreign equity from 40 percent to 51 per cent. A new TNC can automatically have 51 per cent foreign equity (and an existing one can increase it to 51 per cent provided they participate in Appendix industries.

4.2 Response of TNCs

The TNCs have reacted favorably to the new economic policy to enter and to grow in India. Gross inflow of FDI have gone up from Rs 5.3 billion in 1991 to Rs 38.9 billion in 1992, Rs 88.6 billion in 1993 and Rs 141.9 billion in 1994.

The entire amounts of FDI inflows are not being used for greenfields projects. As discussed below, the TNCs are buying up Indian companies increasing their stake in existing companies, etc. Several steps have been initiated which will enhance the managerial control and the market power of the TNCs at the cost of Indian entrepreneurs.

4.3 Mergers and acquisitions

With the virtual abolition of FERA and the monopolies part of MRTP, etc. there has been a sharp rise in the number of mergers and takeovers of companies. A few TNCs have sold out their companies/divisions to Indian-owned companies [31]. For example, the textile tycoon Ajay Piramal has bought out the Swiss pharmaceutical TNC Roche's 74 percent stake in its subsidiary in India. Similarly the Indian groups of Reliance and GP Goenka have taken over the fertilizer and polyester divisions respectively of the British TNT, ICI [31]. Tata Chemicals plans to acquire the phosphoric acid plant of Occidental Chemical Co in Florida. But what has really attracted attention is that a number of
dominant indigenous enterprises which have been competing against TNCs in their respective fields, are succumbing to TNCs. As a result, the structure of a number of industries is changing radically.

For failing to comply with the provision of FERA Coca Cola departed from India in 1977. This paved the way for the growth and domination of the soft drinks industry by Indian firms. About a decade later, the government allowed Pepsi. But the government imposed a number of conditions e.g. an export obligation. The government did not allow unrestricted use of the brand name: Pepsi had to agree with the hybrid name: Lehar Pepsi, Pepsi was not allowed to own majority share. The equity of the company in India was held 44.35 per cent each by Pepsi and Voltas and 11.3 per cent by Punjab Agro Industries Corporation. Pepsi could not dislodge Parle as the largest firm. Parle continued to be the market leader with about 60 per cent market share.

The recent policy changes and the re-entry of Coca Cola in 1993 however have changed the industry to almost 100% TNC controlled. Coca Cola has ousted the market leader Parle, Ramesh Chauhan, the chief of Parle has sold out the successful brands of Parle--Thumps up, Limca, Citra Gold Spot and Maza---to Coca Cola for an amount reported to be $ 60 million Parle now has effectively been reduced to a bottler for Coca Cola.

In the light of the new economic policy and also to ensure quality of treatment between Coca Cola and Pepsi, the government has withdrawn all the conditions previously imposed on Pepsi. As a result, Pepsi has not only bought the stakes of Voltas but also plans to buy out the remaining shares held by Punjab Agro so that it will be a 100 per cent subsidiary. Pepsi has acquired another Indian soft drinks company, Duke, which has a strong presence in the Bombay region. Its market share of 37 percent in Bombay is larger than that of Pepsi's though less than that of Parle's (45 per cent)

Both Parle and Duke hold the government policy responsible for the demise of indigenous enterprise in the industry. The century old concern of Duke initially did not respond to the feelers from the TNCs to come to an understanding. But in view of the fact that the TNCs are spending massive amounts in the industry and are willing to withstand losses for several years to establish themselves. Duke decided to concede. As the 80 year old chief of Duke said, "There would be something wrong in my head if I didn't see the writing on the wall. I have been in the business for 59 years and with the money the MNCs are spending, I simply can’t do well". Again as Ramesh Chauhan pointed out in an interview, "Pepsi was given permission, the government's overall policy was not to open floodgates for multinationals. I knew that I would be able to stop its entry. Today its a very different situation---- It made good business sense to realize the limits of one's potential and bow out -- Indian entrepreneurship can develop only with the government support. Otherwise we will be reduced to just the bunch of traders working on commission”.

Similar apprehensions are being expressed in other industries. Thus the chief executive of Harbans Lal Malhotra and Sons (HML) pointed out that "It would be foolish to sit idle and watch a slow but steady decline of our share of the market (69 per cent) in the face of competition from other superior makers." HML has been for a long time the market leader in the shaving products industry where the entry of TNCs was regulated.
Gillette, the global market leader, operates in India through Indian Shaving Products Ltd. the former was not allowed to own majority shares. It is only recently that Gillette has increased its stake to 51 per cent. Like Pepsi Gillette could not dislodge the market leader. It was only partially successful in India with a 10 per cent market share. However, under the new economic policy, Gillette is now trying to buy out its competitors by using massive financial power. The deal has not yet been struck apparently due to differences among the three brothers who own HML, Gillette, however, taken another Indian company, Wiltech India.

In the ice-cream industry, an Indian company, Kwality has been the market leader with about 50 per cent share. Brook Bond Lipton India (BBLL), a Unilever group company which has recently set up a plant to manufacture frozen desserts has taken over the marketing networks of Kwality in the northern, western and southern regions of the country. Kwality will continue to own the manufacturing facilities, but these will be used exclusively for BBLL. One of the families controlling the eastern region operations of Kwality is still reluctant and hence is not part of the deal. BBLL has also acquired the ice-cream division of another Indian company, Milkfood which is a part of Jagatjit group companies. It has been reported that another TNC Nestle has also started negotiations for tie up with the remaining important Indian companies like Vadila Arun and Joy to market ice-creams.

Soaps and detergent is another industry where indigenous enterprise like Godrej, Tata Oil Mills, Nirma, etc., have successfully competed against the TNCs such as Hindustan Levers and Proctor and Gamble. But the alliances and mergers allowed under the new environment have significantly enhanced the market power of the TNCs Tatas have decided to relinquish control in Tata Oil Mills and merge it with Hindustan Lever. The merger scheme in fact envisaged issue of shares at a discount price to Unilever to enable it to have 51 per cent shareholding in the merged company. RBI however, has objected to the issue of shares at a discount price. Another TNC, Proctor and Gamble has practically bought off its competitor Godrej Soaps. The two companies have decided to float a new company where the former will have the controlling stake of 51 per cent and the latter the minority one of 49 per cent. While Godrej will make available its production capacities and the distribution network. Proctor and Gamble will provide international technology and brands. Godrej has transferred the marketing, distribution and sales rights of all its toilet soap in the market which will compete with the brands of the new company controlled by Proctor and Gamble, justifying the deal, the managing director of Godrej Soaps said that to compete against the TNCs, the company requires financial and marketing muscle which it does not possess.

Bajaj Electricals, a dominant player in the home appliances market has decided to withdraw its products gradually from the market. This is an offshoot of the formation of a joint venture company between Bajaj and US tools and appliances giant Black and Decker. Bajaj will henceforth market the products manufactured by the new company. Another joint venture announced between the two companies having business in the same field is between General Electric (owns 40 per cent equity) and Godrej and Boyce (60 per cent). The new company will take over the latter’s refrigeration division G and B is now the market leader in refrigerators with a share of 45 per cent. The company will also
diversify into compressors, washing machines, dish washers, microwave ovens and other household appliances.

The government's indifference to that status of the indigenous firms has surprised a number of experts. Commenting on the sell out of Parle to Coca Cola, Michael Porter, who studied competitiveness in different countries has pointed out that “Few countries in the world would permit their dominant national player to be brought over by a multinational”. Japanese TNCs have played an important role in Japan's economic prosperity, Saboro Okita, the veteran development economist who had direct experience in economic policy making in Japan in 1960s has advised against an overall opening up Indian industry to foreign investments. Giving the example of automobile industry in Japan, he argued that if Japan opened its economy 20 or 30 years ago, then the Toyota and Nissans may not have existed today.

Some of the Indian industrialists e.g. Hari Shankar Singhania, who is a prominent member of the Bombay Club mentioned earlier, has complained about the pace of reforms. He pointed out that for industrial development, the basic role will have to be played by the indigenous sector. And the government encourages indigenous firms to grow before fully liberalizing foreign investments. It however appears from demands put forward by the Bombay club, that these industrialists in general are more concerned about getting certain financial facilities to enhance their equity holdings and to prevent take over. But undisputed control over their firms is not enough to tackle the TNCs [22]. What is also important is government's support for the indigenous firms to grow vis-a-vis TNCs

4.4 Attitude of foreign investors

The statements of industrialists and executives from abroad who have been visiting India lately, convey the impression that they are more interested in the domestic market than in exports. A high level 50 member strong Japanese business team visited India in January 1992. The leader of the delegation pointed out that the large domestic market in India is a major attraction. To facilitate further Japanese investments, the team in fact requested the government among others not to insist on exports to pay for their dividends repatriation. Addressing the Indo-US Chamber of Commerce, a representative of a large US firm said in January that the restriction on dividend repatriation subject to export earnings has raised doubts about whether India would allow reasonable access to the domestic market. This has made the TNCs skeptical about investing in India.

The president of the Federation of German Industry, who led a business delegation to India said that there are two major motivations for German firms to invest in India (1) domestic market (2) low cost of production base for exports mainly to the Far East. He did not clarify whether both are equally important and if not which is more important. But significantly enough he also asked for the withdrawal of the export obligations.

The conditions of balancing dividend repatriation with export earnings was actually withdrawn in response to the complaints made by the foreign investors. The Press Note which announced the withdrawal of the dividend balancing conditions in fact specifically mentions that this is being done to further stimulate foreign goods into the country [19].
The former chief of the Proctor and Gamble operations in India who has now joined the headquarters in the US said that India's biggest advantage is the large domestic market. The attitude that TNCs would come to India only to export and not to take advantage of the domestic market will not help. A survey was conducted in the US to ascertain the prospects of US FDI in India compared to that in other Asian countries. The survey found that US investors are primarily interested in India for domestic production rather than for exports. Among the 23 factors identified, the most important factor influencing investment in India was found to be the size of the domestic market. The motivation of "exports to the third countries" and exports back to USA are ranked 15th and 20th respectively in descending order of importance.

4.5 Prospects of Export-oriented FDI in India

International production of TNCs actually has traditionally been organized primarily for the domestic markets of the host countries. Export-oriented investments were mainly restricted to natural resources. Studies on the determinants of FDI found that factors such as market size, trade restrictions are much more important than cost factors in determining such domestic market-oriented investments [40].

An important change in the behavior of TNCs over the last thirty years has been the increase in export-oriented investments in manufacturing by the TNCs abroad to take advantage of certain favorable conditions in the host countries e.g. lower cost of labor[41,40]. With the intensification of international competition, the TNCs become more cost-conscious. The fall in trade barriers and communication technologies have made it possible for them to transfer a part of their activities to cheaper locations. Such export-oriented investments, however, were restricted to specified products/processes and these were located in selected countries in Asia and Latin America [40,38].

India was not one of the major destinations for these investments. As discussed in the previous section, the response of the TNCs as of now do not reflect a sharp break from the past. But it may be argued that the period since 1991 is too short to observe such a shift. If we take a longer term perspective, then under the new economic regime, is there a possibility of a significant spurt in manufacturing exports by the TNCs from India? This will depend on the growth of the relocation of production by TNCs in the third world countries and the share of this growth which India can manage for herself.

So far the size and the growth of international production by TNCs in the third world countries is concerned, the future trend is not very clear.

On the one hand. The World Investment Report [38] speaks of the emergence of an integrated global system of production. In the past the TNCs transferred particular activities to locations with cost advantages. They are now slowly moving to a system where all the activities of the firm are potential candidates for being undertaken in different locations depending on the respective advantages. Hence the report predict an upsurge in the volume of international production [38,39].

But on the other hand it is not very clear to what extent the third world countries will be able to take advantage of such increased internationalization of production as and when it takes place. The traditional advantage of the third world countries is the low cost of labor. A survey conducted by the International Finance Corporation on US TNCs
found that new manufacturing technologies have made labor cost much less important than what it was before and hence the third world countries have become less important as export platforms to serve the developed country markets [26]. A number of TNCs in consumer electronics (e.g. Philips) and computer (e.g. IBM, Apple) have already initiated steps to automate their plants at home and shift production from third world countries [42,43,44].

The International Finance Corporation study has also reported that radical organizational changes are being undertaken in TNCs which have negative implications for plant locations in the third world countries. Companies are trying to reduce costs through low inventories and quickness of response. The trend is to locate plants close to the customers. As a result the number of suppliers factories is increasing the average plant size is decreasing [26].

Thus export oriented investments by the TNCs may not increase at the same rate as in the past. Moreover, whatever may be the volume of such investments, the share of India will crucially depend on the advantages she offers compared to her competing countries. To attract FDI for export what is important is not whether the situation is better than that in the past but whether it is better than what the competing countries offer.

It appears from the demands put forward and the comments made by some of the foreign investors as referred below that India compare not so favorably with the competing countries. in terms of (1) infrastructure (2) control over labor (3) priority accorded to FDI etc.

A report of the Far Eastern Economic Review (FEER) sums up the general perception of foreign investors about India as follows.

The Indian business climate is not yet as hospitable as other locations for scarce capital. Wages rates are low, but so is productivity. Labor is highly specialized and powerful trade unions are reluctant to abandon traditional inefficient practices.

Infrastructure is already inadequate: for example, like all industries with continuous process, Dupont is faced with having to provide 100 per cent power back up for its Goa plant. The country has only 5.5 million telephones lines for 850 million people.

Various local levies slow down distribution of materials and products; a truck with a valuable cargo may have to queue for two to three days at a state or city boundary, to pay octroi of a few US dollars).

To facilitate investment from Japan, a business team from that country has specifically requested the government among other things, for an early formulation of exit policy and more investments in infrastructure such as power and telecommunication services. The leader of another Japanese business delegation reiterated that Japanese investments in India are unlikely to increase substantially unless an exit policy is formulated and unions are prevented from interfering with the working environment. The US ambassador to India said that "Expansion in India's power sector will help attract higher levels of foreign investment. A major concern of foreign investors is the lack of a reliable power infrastructure relative to other opportunities in Asia. The government has taken a number of steps to improve the infrastructure facilities. But for obvious political
reasons governments in the exit policy front have been slower than what has been desired in certain quarters.

A conference of leading industrialists, official from World Bank Asian Development Bank, etc. organized by Foreign Investment Advisory Service (a joint facility of the International Finance Corporation and the Multilateral Investment Guarantee Agency) in Washington concluded that India has been unable to attract enough FDI due to "restrictive policies and bureaucratic redtape". The participants felt that a more welcome attitude to FDI is needed in India.

What often matters is not what has been indicated in official policy statements. A study sponsored by ministry of industry of the government of India, reveal that right now the foreign investment policies in India are much more open than most other Asian countries. In China, Indonesia, Malaysia and Taiwan, prior approval of the government is required for foreign investment projects. India in fact is similar to South Korea and Thailand where automatic approval is given for some industries, but prior permission is required for the rest. Only in Singapore no approval is required.

Conclusion

India has opened up its flood gates for multinationals that resulted into vanishing of local industry. Companies like Coca Cola and Pepsi can withstand loses for years together but the local companies cannot compete due to financial difficulties. It may not be good for the country to overlook the interest of the local industries which are struggling for survival over the last few decades. Indigenous technology should be protected in the areas where India has got certain degree of maturity. India should concentrate on selected areas where it has great potential like software industry and achieve excellence to compete in the international market. This could be possible only when India does strike a balance between imported and the indigenous technology. This kind of approach has been adopted by Japan, South Korea and the South East Asian countries. They did not allow multinationals get in unless they have developed indigenous technology by themselves to achieve self-reliance in selected industries. For example South Korea achieved tremendous success in semiconductor area within a very short time by taking target oriented export policy.

References and notes

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46. India is the first country in the world which has passed the Scientific Policy Resolution by the Parliament under the leadership of the first Prime Minister of India Pt. Jawahar Lal Nehru.

47. Technology Policy Statement was issued by the Department of Science and Technology in Jan. 1983. It emphasized the need to plan technical collaborations agreements in ways that would ensure effective transfer of basic knowledge.

48. NRDC is the key agency in the country mainly responsible for transferring research know-how to industry.

49. CSIR is the biggest agency in the country responsible for industrial research. It has about forty national laboratories under its administrative control doing research in various disciplines like Physical Sciences, Chemical Sciences, Biological Sciences, Earth Sciences and Engineering Sciences. The CSIR is hundred per cent funded by the government of India.

50. DST is the government department responsible for funding of sponsored projects to various disciplines of science and technology at Universities and research institutions in the country. It also looks after the international cooperation in science and technology with other countries.

51. Technology Utilization Division is one of the technical division at CSIR Headquarters, concerns with the formulation of rules and regulations for the transfer of know-how developed by CSIR laboratories.

52. Before selecting R&D project it is approved by the Research Council of the laboratory consisting of eminent scientists and industrialists expert in the field. They generally examine the project from the technical point of view.

53. Most of the CSIR laboratories has got the same organizational structure, To streamline the administrative control a laboratory is divided into different research divisions supported by the administrative staff. Big national laboratories like NCL, NPL, CDRI have got the strength of 1500-2000 staff with an annual budget of around Rs 100 million. According to Professor Nayudamma former Director General of CSIR, there is hardly any coordination among the scientist of different divisions. He says, “Scientists would like to work in water tight compartment”.

54. Over the last few years CSIR has made structural changes in the process of transfer of technology: first, it has adopted totally business approach towards selection of research projects, secondly it has established Business Promotion Groups at each laboratory to streamline the transfer of know-how.
Introduction

Japan along with many developed countries has been assisting developing countries to build their technological capability since long. So far majority of development aid projects are implemented through north–south cooperation. In case of Japan, there are several modalities of Japanese development assistance being implemented by the Japan International Cooperation Agency (JICA).

1. North-South cooperation - where Japanese institutions/organizations come directly to assist the recipient countries with Japanese technology. It is a developed country with high technology, which underdeveloped countries cannot easily adapt. Such development assistance may not be as effective as expected, because of socio-economical and technological differences between donor and recipient country.

2. NGO-NGO cooperation – where Japanese non-governmental organization in cooperation with non-governmental organization of recipient country work together at the grassroot level for the development of the rural community. This program is also called the JICA partnership program (JPP).

3. South-south cooperation with support from the north – where developing countries with similar problems and situation seek cooperation and support from Japan.

South-South cooperation on capacity building of Tumba College of Technology

JICA initiated this third model of development assistance to Rwanda through the South - South Cooperation between two similar developing countries Rwanda and Nepal. Rwanda is located in central equatorial Africa whereas Nepal is in South Asia (Figure 1). Although the countries are totally different in terms of location, size, populations, etc; there are still many similarities and commonalities between them. Some photos (Figure 2) of both Rwanda and Nepal show very similar physiographic similarities. They are both hilly countries with agriculture as the main occupation. They are both land locked countries with similar energy problems. Table 1 shows some of the indicators for both the countries.

Biomass is the main source of energy for both the countries. In both the countries more than 80 % of the energy comes from biomass (Figure 3). All petroleum products are imported in both countries. If Nepal uses animal dung as an alternative, in Rwanda peat is used, because the has big deposits (155 million tons) of peat. Nepal is comparatively well developed than Rwanda in the areas of Alternative energy such as Micro hydro, Biogas, Solar, biomass, etc. Keeping in view these circumstances a project to assist Rwanda...
called “Strengthening the Capacity of Tumba College of Technology” was initiated with the support from JICA.

<table>
<thead>
<tr>
<th>No</th>
<th>Indicators</th>
<th>Rwanda</th>
<th>Nepal</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Population</td>
<td>10,746,311 January 2010 estimate</td>
<td>29,331,000 2009 estimate</td>
<td>Nepal 3 times more people</td>
</tr>
<tr>
<td>2</td>
<td>Geography</td>
<td>Country of a 1000 hills – Mil Collins</td>
<td>75 % of land coverage are hills and mountains</td>
<td>Landscape is very similar</td>
</tr>
<tr>
<td>3</td>
<td>Occupation</td>
<td>Agricultural country (90% population) Rice, Tea, coffee 39.4% of GDP in 2006</td>
<td>Agricultural country Rice, Tea, coffee 40% of Nepal's GDP</td>
<td>Crop cultivation is also rain dependant in the hill areas</td>
</tr>
<tr>
<td>4</td>
<td>Staple food</td>
<td>Rice and beans</td>
<td>Rice, dal and curry</td>
<td>Food is similar except for specific items</td>
</tr>
<tr>
<td>5</td>
<td>Religion</td>
<td>Christians and Muslims</td>
<td>Hindu, Buddhist, Christians and Muslims</td>
<td>Some difference</td>
</tr>
<tr>
<td>6</td>
<td>Area</td>
<td>26,338 km²</td>
<td>147,181 km²</td>
<td>Nepal 5 times bigger</td>
</tr>
<tr>
<td>7</td>
<td>Economy</td>
<td>Tourism, Export – tea, coffee</td>
<td>Tourism, Export – tea, coffee</td>
<td>Similar</td>
</tr>
<tr>
<td>8</td>
<td>Per capita</td>
<td>US$ 1148</td>
<td>US$ 1205</td>
<td>Almost same</td>
</tr>
<tr>
<td>9</td>
<td>Energy</td>
<td>Biomass dependant Import all Petroleum products</td>
<td>Biomass dependant Import all Petroleum products</td>
<td>Very similar situation</td>
</tr>
<tr>
<td>10</td>
<td>Language</td>
<td>Kinyarwanda and English</td>
<td>Nepali and English</td>
<td>Language changed from French to English</td>
</tr>
</tbody>
</table>
This 5 year project assistance to Tumba College of Technology (TCT) in Rwanda started from August 2007 and will last till July 2012. A Technical school-ETO Tumba-originally established by Japan in 1992, but destroyed during the civil war, was converted to TCT with the objective of developing higher technicians at Diploma level (A1) with three courses, namely: Information Technology (IT), Electronics and Telecommunication (ET) and Alternative Energy (AE).

Activities of IT and ET departments are being jointly conducted by Japanese and Indonesian consultants. The AE department is assisted by the Nepalese consultants because of the long experience in micro hydro, biogas, solar thermal, solar PV, biomass and improved cook stoves. The Institute of Engineering (IOE) in Nepal has been conducting Master Degree Course in Renewable Energy for a long time. This long experience and expertise of the teachers is the basis for collaboration. This paper will focus mainly on Capacity building in the department of Alternate energy.

Among many activities and different aspects of Capacity building TCT, the project cooperation concentrates mainly on:

1. Basic management system of TCT – development of annual academic calendar
2. Development of Curriculum/Course manual on Alternative Energy
3. Improvement of pedagogic abilities of teachers
4. Training of teachers of the AE department
5. Technology/knowledge transfer through interactions and lectures
The basic management of the department of AE has been set up with an operational academic calendar, through consultation and advisory service of the senior advisors Prof Jagannath and Prof Ale from the Center for Energy Studies under the Institute of Engineering. Initially the curriculum for the AE course was developed and later, based on the curriculum, the course manual was prepared, which is now being used by the teachers for conducting daily classes. The list of the AE department faculty members and the Nepalese experts are given in Table 2. For the improvement of the pedagogic skills of the teachers, more than dozen teachers have been trained in Nepal in all general aspects of AE as well as specific areas such as Biogas, Solar and Biomass.

<table>
<thead>
<tr>
<th>Subject</th>
<th>TCT teachers/technicians</th>
<th>Nepali expert/advisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro hydro</td>
<td>Mr. NZEYIMANA Alain</td>
<td>Er. Krishna Nakarmi</td>
</tr>
<tr>
<td>Mechanical Workshop</td>
<td>Mr. Ndorunkundive Eugene</td>
<td>Er. Krishna Nakarmi</td>
</tr>
<tr>
<td>Solar thermal</td>
<td>Mr. NARCISSE January</td>
<td>Er. Niraj Shrestha</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Mr. NARCISSE January</td>
<td>Prof Dr. Deepak Lal Shrestha</td>
</tr>
<tr>
<td>Biogas</td>
<td>Mr. NISHIMYUMUREMYI</td>
<td>Er. Ravi Bhanu Chettri</td>
</tr>
<tr>
<td>Improved cook stoves</td>
<td>Mr. RURANGIRWA Martin</td>
<td>Er Satish Arval</td>
</tr>
<tr>
<td>Biomass &amp; briquetting</td>
<td>Mr. RURANGIRWA Martin</td>
<td>Dr. Ramesh M Singh</td>
</tr>
<tr>
<td>Electrical engineering</td>
<td>Mr. RURANGIRWA Martin</td>
<td>Prof Dr. Indra Man Tamrakar</td>
</tr>
<tr>
<td>Sociology</td>
<td>Mr. BYUNGA Sylvver</td>
<td>Mrs. Karuna Bajracyara</td>
</tr>
<tr>
<td>Asst tutor</td>
<td>Mr. BAKUNDUKIZE</td>
<td></td>
</tr>
<tr>
<td>Asst tutor</td>
<td>Mr. NZABONIMANAB Gilbert</td>
<td></td>
</tr>
<tr>
<td>Asst tutor</td>
<td>Mr. NDAYIMIYE Nicolas</td>
<td>Senior advisors</td>
</tr>
<tr>
<td>Head of Department</td>
<td>Mr. IYAKAREMIEY</td>
<td>Prof Dr. Jaganath Shrestha</td>
</tr>
<tr>
<td>Technician</td>
<td>Mr. IRAGUHA Etienne</td>
<td>Prof Dr Bhakte B Ale</td>
</tr>
<tr>
<td>Technician</td>
<td>Mr. Fabris</td>
<td></td>
</tr>
<tr>
<td>Industry Attachment</td>
<td>Mr. MICHAEL Rusugara</td>
<td></td>
</tr>
<tr>
<td>Industry Attachment</td>
<td>Mr. James MV</td>
<td></td>
</tr>
<tr>
<td>Industry Attachment</td>
<td>Miss Lilliane</td>
<td></td>
</tr>
</tbody>
</table>

More than 21 visits of (long term as well as short term) experts have been accomplished for the constant engagement in the capacity building of TCT through lectures, interactions, demonstrations, etc. to upgrade the level of technical knowledge of the teachers. They conduct in-house training and practical classes for the teachers as well as students. As a result, the first batch of 142 students, including 52 from AE department, graduated last year and 70 % have jobs and are successfully working in different industrial and commercial establishments.

The working methodology of the experts and advisors consists of formal lectures (theoretical knowledge transfer), classroom interaction/meetings (informal knowledge transfer), demonstration of equipment/instruments to the teachers and students, practical
lessons (hands-on training/practical to make equipment, perform tests), analysis and testing works; evaluation, assessments and tests; dissemination and promotion of AE technologies; demonstration and training to others and sometime participation in EXPO.

Micro hydro sector envisages establishing one micro hydro power station up to 30 KW in future. A small 2.3 KW plant is proposed nearby the boys’ hostel and 1 KW plant proposed near TCT football ground. A small model turbine of capacity 0.5 to 0.75kW fabricated in Nepal already exists in TCT as teaching aid. The plant, which illustrates basic principles of operation of micro hydro plants, is for demonstration and pedagogic purpose e. As recognition of capacity of TCT, GTZ in Rwanda is now in the process of requesting TCT to provide training for people in Micro hydro. 5

Rwanda has plan to setup 15,000 biogas plants in near future and the success story of biogas in Nepal can certainly contribute in technology transfer and training of manpower to fulfill the above plan. The capability of TCT has been recognized by the Ministry of Infrastructure (MININFRA) which has assigned the job of training and installation works in biogas to TCT. The teachers are now busy in the installation and commissioning of biogas plant in different part of Rwanda.

Rwanda still depends on heavily (95%) on biomass energy, including ~ 80% fuel (Figure 3) wood, which is the cause of large scale deforestation. Rural areas still use fuel wood while urban areas use mainly charcoal. About 23 % the fuel wood goes for production of charcoal which is used in the urban areas. Charcoal production is primitive and the yield is very low about 10%. During transportation delivery and sales of charcoal about 10% charcoal dust is wasted and not used at all. Furthermore, Rwanda like Nepal has a lot of waste biomass like banana waste, papyrus, pine needles, eucalyptus leaves, etc., which can be converted to charcoal for making briquettes.
Nepal too depends heavily on traditional energy sources. Technologies that have produced positive impact in Nepal such as improved cook stoves, biobriquettes, cheap fuel saving stoves and charcoal from waste biomass have been introduced/demonstrated to TCT and rural areas so as to reduce fuel wood consumption. Cooking beans is a problem as it takes more than 2 hours, but introduction of pressure cooker has reduced the time more than half. Plenty of waste biomass such as banana waste, papyrus, eucalyptus leaves and pine needles was used to make charcoal using simple charcoal making technology and then converted to charcoal briquettes which were used as fuel instead of wood charcoal.

A small Biomass laboratory to perform different tests (water boiling test, cooking test, combustion emissions, etc) is now operational in TCT, where different organizations are now coming to test fuels and stoves.

Ultimately, technologies are meant for the people to use. Keeping this in mind, TCT teachers have even successfully taken promotional programs of biobriquettes and stoves to the surrounding villagers, displaying their capability not only in the academic
field, but also in promotional program for rural people as well as urban population through participation in the EXPO of 2010 in Kigali that brought TCT a second prize.

Small solar water heaters and solar home systems are the main focus areas in the solar sector with repair and maintenance as an integral part. Initially lectures followed by training are conducted for the teachers and students on fabrication of different components of the solar water heater and solar home system. Finally, they are then given the task to fabricate the system itself. A 100 liter solar water heater and 76 watt solar PV home system fabricated by the TCT teachers and students serves as models for pedagogic purposes.

Findings of midterm evaluation

To evaluate the progress of the project JICA had commissioned a midterm evaluation of the project in November 2009. Some of the findings of the evaluation team have indicated following achievements

- TCT has formulated its operational plan and academic program since August 2007 and is continuously doing every year by itself
- Curriculum has been developed to suit Rwanda and course manual has been prepared in each subject
- Technical, pedagogical and managerial skills of TCT staff have been improved through in house as well as training in Nepal
- The management capacity including employment promotions and income generation activities is enhanced.

Although there has been substantial increase in the capability of TCT, there are some problems, which need urgent attention from the side of the management of TCT. Inadequate salary and poor incentive and motivation factors in the TCT has led to resignation of capable teachers for better jobs mainly in the MININFRA, where development project are a major attraction for them. Such event usually takes place after
completion of trainings. This has been one major setback, which can create problem in the future for this project.

**Conclusions**

So far the results are good till now and provide some basis to draw the following conclusions. This is a unique type of South-south collaboration between developing countries with technical and financial support from Japan. The physiographic, socio-economic similarities and similar energy problems of the participating countries lead to better understanding of the problems and solutions. Communication and working environment between the teachers/students and experts is friendly and more conducive. The technologies, developed and transferred, are simple, cheaper and suitable for Rwanda. Technology from developed countries would probably be more expensive, and perhaps not as suitable for Rwanda. Also the experts/advisors of developed countries probably are more expensive than from developing countries reducing the cost of the project. Any additional or surplus money from cost reduction can always be utilized for additional activities, training and equipment support within the project.

**References:**

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2. The project for strengthening the capacity of Tumba College of Technology, Joint Mid-term report, November 2009

3. Rwanda’s Vision 2020
Back-loading Natech Considerations into Technological Innovation and Application: An Urgent Call for Global Collaboration

Prof. Jay Weinstein
Professor of Sociology, Emeritus
Eastern Michigan University, USA

Beginning with a definition and brief history of the concept of Natech disaster in the field of technological impact analysis, this paper examines the current efforts to contain and/or mitigate this type of event. It concludes with a proposal to develop a specialized approach to impact analysis that will take account of what is now known about these disasters.

Natech disasters are the higher-order consequences of serious technological failures that originate from large scale natural events such as hurricanes, floods, earthquakes, and the like. This complex relationship is expressed in the term “Na” for natural and “tech” for technological. Such events often significantly threaten human life and environmental devastation. “There is sound evidence that natural disasters can trigger technological disasters (a dynamic also called domino effect), and that these concomitant events (also known as natechs) may pose tremendous risks to countries and communities that are unprepared for such risks” (Vetere Arellano et al., 2004).

In addition, it is now evident that these types of disasters have, increased in number and severity during the past several years. There are several reasons for this increase, some of which – such as technological expansion and population growth – are relatively obvious: “There are many instances . . . in which industrial plants, once located far from population centers, are now in close proximity to residential communities. As a result, hazardous materials released from an industrial facility can now threaten the lives and health of large number of people” (Steinberg, 2004). Other, less apparent, factors – often related to second and higher order interaction effects – have also played a significant role. A strong consensus has emerged among those who study this phenomenon that these factors especially require immediate, and international, attention. This had led to the exploration of new approaches to impact assessment that are specifically designed to anticipate and minimize the effects of these disasters.

Taking a sociological perspective, Brunsma and Picou (2008) point to the growth in the number and severity of Natech disasters, the consequent increase in the awareness of researchers, and the early steps that have been taken to develop appropriate assessment tools:

Sociologists are becoming increasingly aware of the changing nature of risk in late modernity and the shifting landscape of the sociological study of disasters. This increased "consciousness of catastrophe" is directly related to the empirical fact that the number of "natural" and "technological" disasters have increased substantially over the past 30 years. In the past eight years, some 422 disaster declarations have been issued in the United States alone – etching disasters as an important part of contemporary American experience. The number of people and communities affected by this most recent spate of catastrophic events reflects a global intensification of death and
destruction that invites analytical and empirical application of a critical sociological imagination. While affecting society as a whole, these "focusing events," or "destabilizing events," have also had an impact on scholarly enterprises, shifting the attention of sociologists from more traditional areas of professional inquiry to the expansion and application of innovative concepts and methods to the study of disasters. This paradigm shift means that disaster research is being actively re-imagined throughout the broader discipline.

The State of the Field

During the past decade, a considerable body of research findings and theoretical analysis has been developed on the subject of Natech disasters (Steinberg, 2004; Cruz, Steinberg, and Vetere-Arellano, 2006; Rennil et al., 2006; Cruz, 2005). Contributors to this work include engineers, environmental scientists, policy specialists and social scientists – literally, from all parts of the world. And, between 2003 and the present, several international conferences have been held on the subject. "The inclusion of a session on natechs at the recent World Conference on Disaster Reduction (Kobe, January 2005) serves as an example" (Cruz, 2005; also see Vetere-Arellano, 2003). One of the most ambitious research programs in the field is the NEDIES (Natural and Environmental Disaster Information Exchange System) project sponsored by the European Commission.

NEDIES is a European Commission project developed in the framework of the DG Joint Research Centre Institutional Programme "Safety and Emergency Management for Man-Made and Natural Hazards" aimed to support EU policies, mainly those of the Civil Protection and Environmental Emergencies Unit of DG Environment, in the area of prevention, mitigation and management of natural risks and technological accidents. Because of the threat posed to society and the environment by this domino effect, the NEDIES project has launched a research activity in this area to assess the state-of-the-art of natech risk management in the European Union (EU) and Candidate Countries, as well as identify needs and assist actors and stakeholders in identifying and prioritizing strategies for natech risk reduction. Because of the importance of this area of investigation and application, the United Nations International Strategy for Disaster Reduction (UN/ISDR) and JRC choose to collaborate in the study of the problem and identification of potential solutions in the framework of a collaboration agreement for the period 2003-2006 (http://nedies.jrc.it/index.asp?ID=67).

Despite these considerable advances, serious gaps exist in our knowledge about the Natech phenomenon and, especially, in the extent to which it is formally recognized and regulated by local and national governments. Ana Maria Cruz summarizes the situation in this way:

However, there is still not sufficient reflection of [the seriousness and prevalence of Natech disasters] in laws of individual countries. For example, country laws generally refer to natech hazards only indirectly as “external” threats, and provisions to prevent or respond to simultaneous disasters from single or multiple sources concurrent with the natural disaster are usually not present. . . . . All of the countries studied have laws and regulations in place for chemical accident prevention, and have adopted measures to protect against natural hazard forces. However, only a few countries have taken steps to prevent or prepare for natech disasters. Most notably in the United States the State of
California requires a seismic assessment as part of the CalAPR rule. Italy is looking at ways to prevent chemical releases and to reduce potential losses caused by flooding. France has modified its environmental law to reflect lessons learnt from past flood-triggered chemical releases and other industrial losses. Industrial plant owners and managers in Kocaeli, Turkey, as well as local government officials are well aware of the need to improve risk management practices to prevent natech disasters in the future.

**Analyzing Natech Impacts**

The advances in knowledge that have been accumulated from this work, along with the nature of these events themselves, suggest that the time has come to apply the lessons learned in a global policy/risk assessment context. “It is emergent to develop tools for the assessment of risks due to NATECH events in the industrial processes, in a framework starting with the characterization of frequency and severity of natural disasters and continuing with complex analysis of industrial processes, to risk assessment and residual functionality analysis” (Boca, Ozunu, and Vlad, 2010). Professor J. Steven Picou, whose research on disasters includes a study of the impact of the Exxon Valdez oil spill in 1989, has recently published a series of papers on the effects of Hurricane Katrina that struck the U.S. Gulf Coast in August 2005. One of his main points relates to the need to reorient our approaches to risk assessment to account for the unique character of Natech events.

Traditional disaster typologies need to be reconsidered for Hurricane Katrina. A reconceptualization of Katrina as a natech disaster reframes the long-term risks of this event for environmental sociologists, disaster researchers and, most important, for the public. Viewing Katrina as a natech disaster forces a consideration of the synergistic contamination consequences overlooked by traditional “natural” and “man-made” classifications, allows for the expansion of disaster impacts to include long-term medical and mental health risks and allows need for government agencies, national NGO’s, community groups, scientific organizations and the media to address the mitigation of these risks for returning residents (Picou, 2009).
The remainder of this presentation focuses on a process akin to technology assessment (TA) and environmental/social impact analysis (E/SIA) that can be incorporated into planning to innovate and/or apply technologies likely to be involved in Natech disasters. This would involve careful study of the ways in which the technology might be compromised by likely natural hazards along with plans to mitigate or eliminate such outcomes – up to and including foregoing proposed innovations/applications. The term “back-loading” is used to underscore the difference between this approach and more traditional types of TA and E/SIA. Whereas in the latter case, the focus of research is on the potential impact of technological innovation on the environment and human activity, and/or application the emphasis in the “back-loading” approach is on the impact of environmental (and possibly social) events on technology.

The assessment of Natech-related risks relies heavily on the concept, first developed by Raymond Bauer and associates, of higher-order impacts (Bauer, Rosenbloom, and Sharp, 1969).

As indicated in Figure 1, below, climatic and other natural events can ultimately impact on economic and social dimensions (third and higher order) through their impacts on intervening dimensions. In terms of Natech disasters, it is the second order that is of most immediate concern.

Because of the substantial intermingling of natural and technological factors, Natech disasters are inherently global in scope, either directly (when global-level resources such as oceanic and atmospheric quality are involved) or indirectly (because higher-order impacts ultimately shift from the local to the global level). Moreover, so many elements are involved in natech disasters: physical, environmental, economic, and sociocultural, it is argued that it is imperative for these assessments to be undertaken by international, interdisciplinary teams.

![Diagram](image)

Figure 2 First- and higher-order effects of climate on aspects of society. As the particular impact becomes more removed from the climatic ‘cause’, more and more interactions intervene to disguise and modify the link. The two-way arrows in the last links symbolize possible adaptive feedback processes. (Ingram et al., 1981)
In discussions of the impact of natural events on the operation of a technology (e.g., the effect of the storm winds and precipitation on the levees in the case of Katrina), it has been observed that the responsibility for risk assessment has always resided with the project engineers – in their calculations of tolerance, etc. Although, this is technically true, the lessons learned from Natech disasters indicate that such engineering analysis must be supplemented at two significant junctures with the kind of impact assessment now under consideration: 1. A far more substantial impact on existing and projected technologies from storm winds and rain, heat and drought, earthquakes, tsunami, and the like needs to be anticipated. What was once considered to be “over-engineering” now needs to be viewed as routine. 2. The assessment of risks can no longer be confined to the effect of environment on the technology. Rather, as an integral part of the process, it needs to be extended to the next order of impact; that is, the impact of technological failure on social and environmental factors.

In Table 1, below, which is adapted from U.S. NOAA guidelines for social and environmental impact, the first two columns illustrate the type of higher-order considerations recommended (although this is just a partial inventory). When we refer to “back-loading,” it is these impacts that are of most direct concern. Whereas SIA positions them at the “front” of the assessment, as end effects, a more complete Natech assessment will also position them at the beginning of the causal chain (as in the third column).
The final graphic (Figure 3) indicates the manner in which the new Natech assessment procedure involves a synthesis of the two existing approaches, engineering analysis and E/SIA. As Picou (2009) argues “natech risk inventories and other comprehensive natech risk methodologies need to be developed” in anticipation of future natural events that “will invariably result in the toxic contamination” and related effects that are now known to be expected. The first steps have now been taken in developing these tools. It is hoped that all parties at interest – governments, scientists, and the general public – will work actively, cooperatively, and internationally to perfect the approach before more tragedies like Katrina occur.
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Prof. Marja Häyrinen-Alestalo
Response of Europe and Asia to the new world Order
Globalization restructuring world order

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In my studies of globalization I have found many Immanuel Wallerstein’s ideas (1976; 1999) of the development of the world system worth considering. Aside from many other explanations of modernization, industrialization and technologization Wallerstein provides a long-term view of the trajectory of the world system that is useful when I have made an attempt to understand and explain recent changes in the world order. His key concept is the capitalist world economy and its swings upward and downward due to complicated political and economic changes. In his view the capitalist economy has played a stabilizing role in the historical process being characterized of a multiplicity of political systems. In fact this multiplicity is one of the reasons why capitalism has been able to flourish world-wide.

Up until recently the capitalist world system has been highly expansive, even though a trend towards the formation of skewed distributions of rewards has been visible. There is new empirical evidence that even the authoritarian regimes can pursue politics that is favorable to the capitalist order (e.g. China). In principle open economies and liberalization of economic activities are necessary, but some big economies such as Japan are still quite closed. Wallerstein (1976) has been willing to speak of an extensive division of labor and of a range of economic tasks which are not evenly distributed throughout the world system. Partly these tasks have been related to geographical divisions referring to old power structures between the advanced core and the underdeveloped periphery. On the other hand, Jeffrey Sachs (2000) tends also to emphasize the importance of geographical divisions. However, his basic argument refers not to ideology but to selective political choices where technology is the primary selective force. Accordingly technological competencies have divided individual countries and even the continents into leaders, followers and losers, the last mentioned countries presenting the periphery. For some part this model is able to explain why for example the Nordic countries have abolished the gap between the geographical core and the periphery. Also the results of my studies have shown how before the last global economic depression their performance was of top quality when economic market competitiveness has been estimated.

To Wallerstein the social organization of work is also important as it legitimizes the ability of core groups to exploit the labor of others and to receive a larger share of surplus. In recent decades analyses of globalization have demonstrated that an increasing number of the developing countries have become not only semi-peripheries but have legitimized their position among those countries which are able to accumulate surplus also for themselves.
Wallerstein’s (1999) analysis of the phases of capitalism is theoretically interesting. Especially the period between the Second World War and the first years of the 2000’s is important in order to understand earlier developments of the world system. Firstly, it is a story of how the U.S. established its dominance, experienced a period of enormous economic expansion and became the only major industrial power. However, what is perhaps more important for today’s analysis of globalization is the process through which it lost this hegemony. Secondly, by describing the changes from the 1960’s onwards Wallerstein provides a narrative of how the Western European countries and Japan entered in the world markets and how the U.S. was incapable to answer to their expansion. This notion is good to remember when the current incapability of the U.S government to regulate its economy and the global impacts of its collapsed financial system has been discussed all over the world. The old narrative from the 1960’s illustrates how Europe and Japan, the two new world system players became more competitive also in the markets of the developing countries and even in those of the U.S. itself.

The deep economic depression of 2008-2009 - that has been called the first actually global economic turbulence - has provoked discussion of the current problems of capitalism and of the need to elaborate alternative strategies to promote modern world system development. Also Wallerstein has posed a question why the global economic depression in 2008-2009 was so deep all over the capitalist world and why it did not follow the same formula as before (Suh 2009). Today the world economy is in a multi-polar situation and the rise of the developing economies, primarily in Asia but increasingly also in Latin-America and Russia has broken the traditional idea of world hegemony. Globalization is also full of new inconsistencies which make it difficult to govern and to estimate both long-term and short-term outcomes. In the view of Wallerstein the risks are now too great and the profits too small.

In Wallerstein’s terminology capitalism is today in a new phase, perhaps also in the middle of a crisis where the demands for open economies and democratic governance are different from those before (Suh 2009). Due to increasing inconsistencies in wages, input costs and taxation, it is hard for the old hegemonic players to find new solutions. The old model of the capitalist world order has been based on the exports of unemployment from the developed countries to the developing ones. This strategy tends to keep the price of labor cheap and to deepen the skewed distribution of rewards. Of course, the developing countries are still the places where labor is mostly cheap and the profit easily goes to foreign monopolies. New possibilities are increasingly open, not only for high tech off shoring but for the establishment of industries that can no longer be called low-cost industries and services.

**New leaders of the world economy**

Today in the U.S. and Europe various economic scenarios and also the media are full of explanations and news of the extremely rapid growth of the economy in China and India. Both countries were affected by the 2008-2009 global economic depression but they have recovered more easily than the old hegemonic countries. Increasing attention to the economic performance of these two countries indicates that the old core countries are worried about the consequences of the new world order. It also seems that they have not been prepared to meet the various challenges of new global dynamics. As a matter of fact
they have been more defensive than analytic in their efforts to understand the latest phase of globalization. The European Union is still very protectionist and most of its member states such as Finland want to speak of globalization as an organized adaptation process. Adaptation refers not only to a defensive strategy but is also passive by its nature as the focus is more on the past and the present than on the future. A more aggressive policy is also more difficult to pursue as the pressure is to find an answer to the question: what are the possibilities to solve the problems of the present capitalist world economy? This question should be asked both by the developed and the rapidly changing developing countries.

In this article I am making an effort to sketch a picture of the changing world order that takes into account economic, social, ecological and ethical/moral issues. A critical view of the new global order cannot be presented if social, political and also moral criticism is lacking. Aside from theoretical discussion I present some rankings to provide empirical data. Of course the rankings are highly dependent on the validity of the chosen indicators. Even though their validity may be questioned, they indicate many problematic peculiarities of modern capitalism. In the midst of much talk of economic growth and international market competitiveness, they demonstrate processes which are already here waiting for their solving.

Table 1. Leading countries in world economy by nominal GDP

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<th>2000</th>
<th>2010*</th>
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<td>Mexico</td>
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<td>12.</td>
<td>South Korea</td>
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<tr>
<td>15.</td>
<td>Netherlands</td>
<td>15. Netherlands</td>
<td>15. South Korea</td>
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*) estimates

Source: IMF, World Economic Outlook Database of October 2010
It is true that the GDP as an indicator of economic performance can provide only a crude estimation of national investments in the world economy. These statistics are, however, worth considering as they are mostly used as the basic information when the policy-makers make important decisions of the strategies of globalization.

The data in the Table 1 has been collected by the International Monetary Fund (IMF). The table repeats the rapid economic rise of China as a world economy player. The IMF’s newest calculations even indicate that China has already passed Japan in 2010. According to a recent estimation of the World Bank, China will go ahead of the U.S. in 2020. On the basis of further studies of the World Bank the developing countries have become the engines of global economic growth as half of this growth comes from these countries. In the view of the World Bank economist Otaviano Canuto the developing countries have saved the world economy as their economies grow faster than those in the developed countries.

Today both China and India serve as the models of the Asian success story. In many respects they are still different. Moreover, when the primary attention of the Western advanced countries has been on these countries, the picture of recent global economic restructuring has remained too simplified. According to Table 1, countries such as Brazil, Russia, South-Korea, Australia and Mexico are also increasingly important players in the world system. Moreover many new blocks have been established such as the one between China, India, Brazil and Russia (the so-called BRIC-countries). The BRIC-block has started to pursue an expansive foreign politics in Africa. Harold James (2008) has emphasized the coming of a new hegemony. He even calls the new comers in the world economy highly imperialistic countries which due to their many weaknesses bring new instabilities to the world order. As a matter of fact market economy has come to Africa through China. China wants to call this expansion as a mutual economic cooperation. The African countries like this term as it does not repeat the imperialistic echoes of the traditional development aid.

**Current problems in the capitalist world order**

The Western hegemony has been based on the concept of capitalism that through liberalization and open economy is able to respect democratic values. Wallerstein’s idea of the expansion of the skewed distribution of rewards comes close to the aims of a modern competition state that especially in the Nordic welfare states has built tensions with the former government regulated welfare state (Häyrinen-Alestalo 2009). The experiences of the Western competition state and of the European Union demonstrate that democracy does not go hand in hand with the selective processes of market competition. The democratic equalization process and also even the newest ideas of the delivery of public services are linked to elements that are non-marketable by their nature and need a respect of different values than of those that follow the logic of market forces. These issues are therefore politically sensitive. Moreover even the most sophisticated means of capital accumulation are never neutral and the process is highly selective because the winners should be identified in order to make the system functioning.

As I mentioned before Wallerstein is willing to speak of unemployment that the old hegemonic countries have exported to the underdeveloped and developing countries, i.e. the core needs cheap labor from the periphery to maximize the profit for the
exporters. When the power structures of the world system turn upside down in favor of the developing countries, new kinds of questions have to be posed.

The workforce in China is becoming more expensive and the problem of ageing population is acute also there. In India population is young and the workforce is still cheap but it is also highly sophisticated. An important question is therefore: how long can the developed capitalist countries continue to export their unemployment? Are there still areas also in the future where the labor is cheap as long as the exporters hope it to be? What happens to the capitalist system when labor comes too expensive? Or as in China the workforce is also getting as old as in Europe? As globalization tends to be more uncertain than before, it is more difficult to estimate the future of the world economy.

The report from the Conference on “Globalization and Regional Security: Asian Perspective” that was held in Honolulu in 1999 already mentioned several core characteristics of globalization that reflect the new situation from the Asian viewpoint (www.apcss.org/Publications/Report_Globalization_in_Asia.html). It points to 1) unprecedented economic interdependence, 2) the rise of new actors that challenge state authority, 3) growing pressure on states to conform new international standards of governance, particularly in the areas of transparency and accountability, 4) the emergence of a Western-dominated international culture and 5) the rise of severe transnational problems that require multilateral cooperation to be solved. The report also emphasizes the changing role of the authoritarian regimes and points to their increasing fear from globalization. Pekka Haavisto (2010) has made a good analysis of the rising Africa in the world system. He takes an example of the economic collaboration between China and Africa where nobody wants to discuss the problem of the lack of democracy, the role of corruption or the need to respect individual rights. The lack of transparency characterizes also modern Chinese society in general.

The European Union in front of new pressures of globalization

The basic idea of the European Union has always been hegemonic. All versions of the Lisbon treaty emphasize the need to rebuild the European dominance, i.e. to become the most competitive knowledge-based economy in the world. Up until today the competition has been based on the performance comparisons between Europe, the U.S. and Japan. This block has been one of the greatest losers during the last economic depression.

By following Wallerstein one can see the EU’s strategy to rest on the idea of old hegemonic division. Even though the aim has been to develop a highly liberalized and competitive economic system, the EU policy has also included protectionist aspirations to make Europe more resistant to global turbulences. This policy has not been effective and a majority of the EU member states have been vulnerable in front of the new problems of the capitalist world order. Some of the old member countries are also severe trouble makers for the stability of the EU’s economy (Greece, Ireland, Spain, Portugal) and their problems have provoked discussion of a profound crisis that the EU has to solve.

Recently the internal weaknesses have made the EU more sensitive to the requests of new world order. “Europe 2020” in 2010 provides a reformist strategy for Europe to emerge stronger from the economic and financial crises of 2008-2009. It underlines that Europe still has many strengths such as a talented workforce, a powerful technological
and industrial base and a single currency. The talented Europe is still vulnerable when the fight for global high-level competencies becomes more severe.

Europe 2020 that is called “A Strategy for Smart, Sustainable and Inclusive Growth” is putting forward seven flagship initiatives to catalyze the progress. They are as follows: Innovative Union, Youth on the move, A digital agenda for Europe, Resource efficient Europe, An industrial policy for the globalization era, An agenda for new skills and jobs and the European platform against poverty. As before these are only political hopes and there is no guarantee of their accomplishment in the midst of an increasingly risky global future.

Some new steps towards a better understanding of the new global order are, however, taken when considering the above mentioned initiatives. A sharper view of the EU’s new conception of the world system can be found from the European Commission’s report “The World in 2025. The Rising Asia and the Socio-Ecological Transition” (2009). It repeats Wallerstein’s ideas of the rise of new hegemones in the core Asian countries and presents several dramatic changes that the EU must solve the problems of the new world order.

“The World in 2025” also refers to the coexistence and competition between several types of capitalism that can be found in the emerging and oil producing countries. Here the EU speaks of state capitalism. Nevertheless, it is not clear what does the EU mean by the state capitalism. Is it something that needs a shelter from the state? Or is it based on the idea of a return of the state that was mentioned by some policy-makers in the developed countries during the last economic depression? A return of the state points to the need to revise the logic of capitalism and to bring in alternatives that are able to question the logic of severe market competition.

Is the knowledge-based economy capable of homogenizing global interests?

One of the basic arguments of the knowledge-based economy is that knowledge and capital can compensate industrial labor. In the view of Luc Soete the knowledge-based economy is an economy without national borders. The focal point is the capability of national economies to attract foreign capital. This is of course true but also Wallerstein’s ideas are worth remembering. For him the most problematic issue is the decreasing possibility to find a balance between cheap labor and increasingly expensive capital. In the frame of the knowledge-based economy knowledgeable workforce tends to be the most expensive.

Both the EU and the World Bank have stressed the importance of globalization in the development of a stronger knowledge-based economy. One of the basic tenets is that the economy that is based on high quality knowledge and competencies should promote the science system, the development of high technologies and higher education. A similar argumentation can be found in the future scenarios of the key Asian countries, even though China has only recently revised its science and technology policy to make the country more independent of the transfer of foreign technologies and to strengthen its young system of higher education. In fact it was only in 1994 when the making of academic research became possible. New Chinese aspirations are focused on the development of high tech that is close to industries, on the push of industry to invest
more in their own R&D and on the efforts to diminish the dependency on foreign technologies. All these efforts reflect the idea of the knowledge-based economy.

India has chosen a more individualistic strategy. Starting from the Prime Minister Nehru’s time the government has stressed the importance of national efforts to develop own high tech. One can also find much talk of a selective technology transfer. For many years the educational plans have been ambitious and several long-term plans have been elaborated in order to systematically invest into the science and university systems. Still India has serious difficulties with the amount and quality of various types of universities. Due to still existing class divisions and enormous poverty of the population the efforts to equalize the opportunity through higher education is a serious problem in many respects. However, the emphasis on the ICT-type technological advancement serves the ideas of the knowledge-based economy.

As there are increasing global emphasis on the knowledge-based economy it is interesting to see how the main global actors invest in research and development. Even though once again the GDP is not any ideal measure, the Figure 1 gives some evidence of the variation of R&D investments world-wide.

**Figure 1. R&D Intensity in selected countries 1995-2008 (R&D expenditure as percentage of GDP, %)**

![R&D Intensity Graph](#)

Source: OECD Fact Book, 2010

As Figure 1 shows the financing of R&D in the old hegemonic countries is still important even though the Nordic countries, such as Sweden and Finland have made investments as high as 4% of GDP. The European core member countries have a much lower position in the R&D-based world order and their investments indicate only a moderate growth.
As regards the rising economies in Asia the picture is not clear. China has strengthened its position by increasing the R&D expenditure in a short time being close to the U.S. in 2007. The curve illustrating the performance of India differs from the great promises the country has given. As a matter of fact there seems to be no growth of R&D expenditure at all.

Of course the comparisons between the old and new hegemonies and their recent R&D investments cannot only be based on data that reflect the attempts to develop a high tech- and market driven knowledge-based economy. A very fruitful way to look at recent developments is to pay attention to the results that the United Nations has published in its report series of global human development.

Especially the 20-year Anniversary Report (2010) is important in this respect. According to the comparisons of the UN in 1970-2010 Oman, China and Nepal have made the highest progress in human issues when the level of income, estimated lifetime, equalization of the opportunity between the sexes and the abolition of poverty are considered.

All in all the rankings on the basis of human development in 2010 is as follows:

1. Norway
2. Australia
3. New Zealand
4. The U.S.
9. Sweden
11. Japan
16. Finland
65. Russia
89. China
119. India

This ranking reflects different kinds of positions in the world system than the Table 1. New indicators are needed when an attempt is made to convince the global players of the necessity to develop a good society not only a highly competitive knowledge-based economy.

**Climate change restructuring world order**

In my analyses I have tried to demonstrate an increasing trend to see reorientations in the world system through the lenses of capitalism and of the market forces logic. Globalization is, however, full of new disorder and world-wide disasters that point to the need to identify various types of global risks and to solve their consequences. Issues of climate change and new energy technologies belong to these global duties.

The Lund declaration that the European Union published in 2009 pays attention to the grand challenges of our time that the EU must focus on. Among them are more issues of global solidarity than before. Also the World Bank in its ongoing Knowledge for
Development-Program emphasizes inclusive and sustainable aspects of globalization. Today sustainability as a global effort refers to climate policy, especially to global warming due to greenhouse gases. In this frame, new responsibilities, divisions of global labor and reorientations in the ways of understanding the input-output relations and of capital accumulation are needed. Many European governments have started to underline that the new questions of humankind’s destiny wait for their solving. The former advisor of Japan’s government Ayao Tsuge has been willing to speak of a new global model that he calls globally sustainable innovation-based eco-system. What does it mean as an actual political reform is not clear?

It is characteristic of the revised concept of globalization that it can no longer be regarded as the primary mover in the world order. In fact, climate change is not able to regulate the process of globalization. Climate warming alone can change the labor markets in Europe and all over the world. The borders between the countries have to be abolished, not due to the aspirations of expansive multinational firms but due to climate disasters such as the lack of water, lost crops, as well as heavy storms and floods. These transformations request for structural changes in the world economy both in the developed and developing countries. There is a nasty estimation according to which there will be a huge increase in number of world refugees that somebody has to take care of. Of course these transformations set demands for new adaptations. Still the key question is the same that Anthony Giddens (2009) has already posed: Are we too late ? Is the political system too hopeful because so many disasters have already happened?

Once again climate issues are highly politicized and both the old and new hegemonies have various interests to fight for. International agreements are necessary but the experiences for example from the latest climate change negotiations arranged by the United Nations have not been promising. The agreements are also full of compromises. Moreover increasing global demands have been set to the negotiations between the U.S. and China which are the greatest producers of greenhouse gases. The EU has also requested clear norms and standards only after it is ready to make a global climate deal. The developed economies are waiting for the commitments of the developing countries before they are ready to make their deals and vice versa. Not only ecological but also moral criticism of the goals of the new global order is therefore an acute task.

In the frame of the knowledge-based economy, climate change has been seen solvable if only new technologies will be developed and more efforts are made to increase investments in science, also in basic science. In Europe there is an increasing talk of a green economy. Green knowledge has been on the top of ecological modernization for some time in the developed countries but the capitalist world order has not been so eager to promote the coming of the green economy. Only a few evidence can be found of the capability of old hegemonic countries to provide new “green jobs”.

I will end my article by showing Table 2 that illustrates the top of the worst CO2 emission countries. For some part the rankings go to the same direction as in the Table 1. The message of the Table 2 is, however, linked to the critical view of the current world order. Aside from the U.S. and Japan the new global powers, such as China, India and Russia have entered the world scene by producing most of the CO2 emission.
Table 2. The worst CO2 emission producers in 2006.

1. China 6 017 million tons
2. The U.S 5 902 million tons
3. Japan 1 246 million tons
4. India 1 293 million tons
5. Russia 1 704 million tons
6. Germany 857 million tons
7. Canada 614 million tons
8. Great-Britain 585 million tons
9. South Korea 514 million tons

Rest of the world 9 987 million tons
Finland 66 million tons
Total 29 190 million tons

When an adjustment is made to the number of population, the most climate polluting countries in 2006 were Australia, the U.S. and Canada. No promise of the coming of the green economy has become evident from Asia. The growth of CO2 emission has been fastest in China and India.

John Talberth (2008) has discussed new indicators of modern global progress and has paid attention to the need to elaborate goals that:

1) will motivate the achievement of true progress that is based on all dimensions of human wellbeing
2) will make more rapid the use of renewable energy sources
3) will guarantee more possibilities to distribute resources in a democratic way
4) will protect nature capital
5) will promote the transformation towards local economies

These goals tend also to broaden the range of decision-makers and set demands for free discussion forums where the citizens are equal partners in the making of decisions of the new global order. In the present world order capitalism has been able to flourish even in the authoritarian regimes. In the future, will it be called a green economy or some other mode of an egalitarian society? This kind of strategy cannot be possible.

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Impact of science and technology on rural development

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Preliminary Remarks

The Focus of this paper is on rural communities and societies. They have been during centuries the main centers of human innovation and regeneration. Their traditional strength rely on their ability to generate and maintain cohesion among culture, productions systems and environment as main components of the human habitat. Despite the increasing urbanization and industrialization during the last two centuries, rural communities still concern the largest part of world land use and population.

The degeneration of the market conditions generated by capitalist industrialization in Western countries, of the urban living conditions and of the natural environment has given rise to a number of demands and objectives that modern societies have not been able to satisfy and achieve through increasing technological capabilities and regulations. Therefore a critical reconsideration of the implemented policies, markets development and current problems is needed.

Rural Communities and Agriculture

Agriculture has for a long period in history been the main production system of rural communities, integrated in their social structure and organization, their habitat and their culture and belief. The increasing urbanization and trade relations have segmented agriculture in market and no-market sector and the prevailing role of the former has made it a production system independent from community life. The commodification of this sector concerns mainly agriculture and forestry (80% of the European Union) with great consequences on land use and rural communities in the various regions. The proclaimed aims of this transformation of the agro-industrial system were of matching supply and demand, improving quality, reducing dependence on external supply, etc, but also of reducing the development gap between rural regions within the European Union, and of preserving the overall and regional specific ecological balance.

The strong development achieved in Europe by the agriculture sector since the 1970s is due to the impact of technical progress (improved yield, mechanization, development of the agro-chemical sector) that has required more and more land and capital. The positive outcome of this techno-economic model has been strong spurt in productivity and the achievement of self-sufficiency for a wide range of agriculture commodities, but it has also produced huge structural surpluses of some farm products, the decline of the many multi-purpose farm substituted with the high concentration in more specialized production units, a strong fall in the number of farmers, multiplied environmental degradation (nitrate pollution, erosion, etc.) and a dramatically rise in spending on intermediate consumption energy (energy, fodder, fertilizers pesticides, etc.).

The southern and peripheral traditional rural areas of the Union that host a high proportion of occasional subsistence farmers, with enormous spare production capabilities and plenty of room for structural progress, have lost their production...
capabilities. Therefore it can be stated that the overall objectives of modernization of the agro-industrial system and territorial cohesion have been overtaken by an increased productive and territorial concentration of the agriculture sector (less than 20% of it is today responsible for 80% of global output in Europe). Finally, the dynamic of the agriculture sector has been almost totally separated from the one of the rural communities.

The environmental issues concern the way in which farming practice aggresses the natural environment and the problem of loss of biological diversity. The measures taken so far to protect the environment have been contrasted by production standard and activities which tend to inflict damage. The guidelines seem still to be inspired by the externalities principles by which environmental, human and social costs are not prevented but compensated or punished ex post. The problem is still the one of how to incorporate the environmental factor into the normal behavior of economic life in the way this has been and still is done as a natural part of daily life in rural communities, due to their religious, cultural and social behavior. In modern agriculture and industry, juridical norms and regulations are not able to compensate for the negative attitudes of modern business communities. The attempt to target technological choices taking account of environmental criteria and the improvement of our understanding of the functioning of the biosphere have not be able to avoid the loss of biological diversity. The problem is not to develop alternative or appropriate technologies, but to maintain and sustain mode of production that have shown during their history their ability to adapt and interact with various environment.

The experiences with farming and forestry in Europe and elsewhere demonstrate that what is needed is not just a matter of improving the competitive position of these sectors, or only matching demand and supply in order to reduce external dependence for certain products. The current trend of increasing abandoned farmland and forest worsens the environmental problems. The problem concerns all the rural environment and this requires the revival of local artisans and manufacturing activities, the supply of local services in the field of tourism, leisure, health and local products making more balanced use of the territory.

The revival of huge rural areas requires that we take into account the diversity of climate and soil conditions as well as the specific socio-economic conditions. Therefore standardized managerial criteria based on the degree of intensity and use for farmland and forestry applied for certain areas (North and Centre-North in Europe) cannot be applied for progress in the South. While the mass production of commodities with low value added will continue to exist in the context of world market competition for a small number of producers situated in regions with favorable agro-climatic terms and with good production and marketing structures, rural communities have space to specialize in high value products, less dependent of economy of scale and product standardization. The establishment of this dual lines of development for agriculture, forestry and fishing activities must have implications also for the orientation of R&D and innovation. 49

Urban and rural dimensions

The problem of the decline of rural communities and production systems is of course the other side of the increased rise of megalopolis very often characterized by a chaotic growth and very poor quality of life. The outcome of this spatial development is the impoverishment of the rural centers and smaller cities with emigration toward big cities. The “rural space” lose its population, institutions and local infrastructures, and local trade and distribution chain decline as well as the local production systems. Local production and products disappears from the market while the “urban space” receive its agriculture supply through the big distribution and service network of very often imported commodities. Big cities require new infrastructures, transportations, institutions and services and this drains local areas of needed financial means and infrastructures.

The overall un-sustainability of these patterns of spatial development has become clear in recent decades. The problem of regeneration of rural centers and communities, the maintenance and sustainability of small and medium sized urban centers through the regeneration of local production system and the organization of public transportation systems has been raised again.

For the Revival of the Communities

Rural communities have regained attention at the policy level in recent years because of their potential positive impact on:

(i) agro-industrial development (matching supply and demand, reducing dependence on external supply of some products, etc.);

(ii) social and territorial cohesion among different rural regions within a country or wider areas (such as the European Union);

(iii) environment maintenance and preservation.

The catching up attempts made to control the power of financial groups and transnational corporations by means of policies and regulations have failed in Europe as well as in other part of the modern world, and therefore the need of radical changes in market and consumer behavior, in entrepreneurship and business culture is rising. New popular movements are pushing for new demands for "slow-food", "Km0", "short chain between producers and consumers", "water as common good", and shifting paradigm "from ecology to ecosophy", etc. To this positive trends belongs also the demand for greater autonomy by local and regional institutions world-wide. The impact of Globalization that is weakening the role of national government in defense of national interests is producing a reaction manifested by the revival of cooperation among mega-regions, the centrality of local development, and their orientation toward greater independence form the dominating trends.

The issue of sustainability

The issue of rural communities and sustainability concerns technological, institutional and government innovation as well. In the European case it has become an integrated part of the overall project for the transformation of European societies “from
welfare state to welfare society”. The transformation from welfare state to welfare societies, based on the new social pact for the Common Good, requires the correct definition of three areas: (i) Community welfare (ii) Associative and cooperative welfare (iii) Personal welfare.50

(i) Community welfare:

“is constituted by the whole of principles, institutions, means and practices taken by society in order to guaranty for all its citizens the right to a human decent life and a peaceful, suitable and cooperative ‘living together’, to preserve one’s “home” security, that is to say the sustainability of the local and global ecosystem; and overall taking into account the right to life of the future generations.”51

The common good is the basis of the communities’ welfare on which the associative and personal welfare can be built.

(ii) Associative and cooperative welfare:

“is constituted by the whole of principles, institutions, means and practices taken by society in order to promote voluntary cooperation among people, and/or groups that pursue common objectives by putting at common disposal and sharing the material and immaterial resources following the practices of mutuality and cooperation.”52

Deprivatising means to extend the area of de-commodification to new forms of organization of the private sector able to promote and establish cooperative and associative economic forms belonging to the concepts of the “other economy”, “economy of solidarity” and “districts of solidarity”.

These new areas of activity and socialization comprising of the production, consumption and services, can be developed if they can develop an autonomous space, inside and outside the market economy, able to develop participation, and various forms of social benefits coherent with its own inspiration. These social forms of organization and management of the economy ought to get rid of juridical constraints introduced by the institutions in order to protect monopolistic positions on the economic and institutional side as well.

(iii) Personal and private welfare:

“Personal welfare is constituted by the whole of principles, institutions, means and practices taken by society in order to permit each individual, in competition with all the others, to optimise his own personal utility in term of monetary wealth and freedom of action”53.

This sector of the private economy ought to regain its strength on the market economy re-establishing its links to the real economy by pursuing enterprise profit within

52 Petrella R., Ibidem: 139
53 Petrella R., Ibidem: 139
production and service channels liberated from “bonds” and “constraints” imposed by the financial systems, and by an unnecessary excessive state’s burden on the enterprise’ costs and management. The creation of an enterprise culture able to internalise social costs, to remain within the boundaries of non war’s production, to contribute to the establishment of a just relation among production, distribution and consumption in society, open to the dialogue with the community and the society it belongs to, seems to be a realistic objective.

These guidelines enable a group of individuals to constitute a human community, “to create society”, and live together in such a way as to ensure the right to a "decent" life (in accordance with human dignity) to each member as well as collective safety; all this while respecting "the other" and in solidarity with other human communities and future generations, while safeguarding life on the planet.

**Establishing new tangible and intangible common assets in pursuing citizen well-being.**

The Common Goods are the instruments needed by a welfare society, where they ought to reflect the contents and the forms of the solidarity aim at the achievement of the Common Good. They are the goods necessary for material life as well as to new activities and relations perceived of central importance in the life of the communities. Therefore they ought to be characterized differently from the private goods (commodities) where the principles are those of rivalry and exclusivity in access and use applied in the capitalist market system. The public economy and cooperative economy function in a different way in the market economy from the capitalist one.

A first screening of the common goods includes: air, water, state lands, seas and forests, space, energy, knowledge, transportation, education, health, communication and information, security, justice, basic financial activities and political institutions. Among the Common Goods we find also labour and culture whose roles, functions, times and forms are narrowly intertwined with other forms of social life. Common Goods of world wide importance should be matters of communities’ dialogue for their maintenance and use within the perspective of “living together” *(Table 1).*

**Table 1. Common goods, actors and pratices, well being**

<table>
<thead>
<tr>
<th>COMMON GOODS</th>
<th>ACTORS AND PRACTICES</th>
<th>WELL BEING</th>
</tr>
</thead>
<tbody>
<tr>
<td>- air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- water</td>
<td>ACTORS:</td>
<td>SUSTAINABILITY:</td>
</tr>
<tr>
<td></td>
<td>- institutions</td>
<td>- Environmental</td>
</tr>
<tr>
<td></td>
<td>(such as representative democracy, local community institutions, free trade unions....)</td>
<td>- Social</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Cultural</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Political</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Economic</td>
</tr>
<tr>
<td>- “green” energies, such as water</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
solar energy, aeolian, etc.)
- *State lands and forests*
- *aether and extra earthly space*
- *knowledge* (in all its various forms)
- *education* (in all its forms)
- *habitat* (from housing to the government of the territory)
- *health*
- *culture* (specifically cultural goods)
- *common transportation*
- *communication and information*
- *common security* (police, army, civil protection,)
- *justice*
- *financial common institution* (Treasury, popular savings banks, …)
- *political institutions* (parliament, government, public administration)

- *social enterprises* (SMEs, cooperatives, social cooperatives, etc)
- *civil society organizations* (NGOs, associations, etc)

**PRACTICES:**

- *principles* (such as the principle of the right to life for all, the precautionary principle, the principle of equal citizenship, the principle of the finiteness of most of the planet's resources...)

- *practices* (the practices of common sharing, individual and collective solidarity...) “

The resources at disposal for the welfare society project inspired by the Common Good are:

- a) values and principles
- b) laws and institutions
- c) finance
- d) actors and practices

The recent trend toward the segmentation of Common Goods to be managed by international agencies (“governance”), reproduces the negative effects experienced with
the Public Goods administered by the State, followed by communities’ and people’s lack of sense of responsibility. Therefore the selection and the government of the Common Goods should re-establish the principle of sovereignty at community level versus the State as well as toward international institutions. This implies the introduction of new ownership and management forms based on high level of self-government and participation able to mobilize local communities and civil societies.

The economy cannot remain outside and independent from this system, as in the case of the welfare State built on the dualism between State and Market. This dualism is today challenged on two sides. Globalization, by increasing privatization, transforms dualism into a unified system based on the principle and supremacy of finance and technology with the marginalization of increasing areas of society. An alternative answer to this problem is the Common Good that overcomes the dualism of the previous system by re-establishing the centrality of a community life based on its main components: territory, population, production systems and institutions. (Figure 1).

**Figure 1 – THE DIAMOND OF THE COMMUNITY**


The life of the communities inspired by the Common Good requires an overall cohesion and mobilization of all its components and resources. The common goods create the basis for its overall functioning and within each of its main factors: territory, production systems, population and institutions. The diamond represents the necessary structure built on its main pillars. Globalization is based on de-territorialized production systems, on nomadism of the population and on centralised institutions. The cells of welfare societies are the communities that demand within their respective boundaries the existence of own institutions that govern a specific territory, population and production systems. (Figure 2)
In all forms of social organization, the production system and the market can play an important role as an instrument of social and cultural exchange of experiences, and a place of meeting and elaboration. But this can take place only if a strong link among territory, population, production systems and institutions is maintained without the
decline or disappearing of any of these factors. Therefore the central position given to the local dimension in designing the new boundaries of the community (instead of the national State dimension) is not a choice of specialization within a bigger domain, but the privileged areas of reference to which the other dimensions – such as state, regions, international institutions - ought to be functionally related. *(Table 2).*

**Table 2 – WELFARE STATE, GLOBALIZATION AND COMMON GOOD**

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>WELFARE STATE</th>
<th>GLOBALIZATION</th>
<th>COMMON GOOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Individual and Material</td>
<td>Individual - Status</td>
<td>Social Relational</td>
</tr>
<tr>
<td>(b)</td>
<td>National Growth</td>
<td>Global Apartheid</td>
<td>Common Good</td>
</tr>
<tr>
<td>ACTORS</td>
<td>Individual actors</td>
<td>Consumers choice</td>
<td>Persons accession</td>
</tr>
<tr>
<td>INSTITUTIONS</td>
<td>National State</td>
<td>Triadic Power</td>
<td>Community, region, state and Mesoregions</td>
</tr>
<tr>
<td>POLITICAL FORMS</td>
<td>Government</td>
<td>Governance</td>
<td>Self-government and participation</td>
</tr>
<tr>
<td>POLICIES</td>
<td>National development</td>
<td>From Global to Local</td>
<td>From Local to World-wide</td>
</tr>
<tr>
<td>PRODUCTION SYSTEMS</td>
<td>Public and private enterprises</td>
<td>Transnationals (Toyota Model)</td>
<td>Social enterprises, SMEs Networks, Public Economies</td>
</tr>
</tbody>
</table>

**Role of collective ownership and shared heritage**

The second half of last century has witnessed two stages in the development of European economies. The first two decades – the fifties and sixties – have experienced the planning system in Central and Eastern Europe, and capitalist market and mixed economies in Western Europe. Both systems produced economic growth and a strong rise
of public institutions and services. During this stage planning and market economies were able to satisfy most of the demand for goods and services and almost no space was left to the development of other forms of economy. The existing cooperative movement in the East and in the West was squeezed between market and state and could survive in a very narrow space often adapting itself to the behaviour of the prevailing economic system.

The situation changed radically in the following decades (1970 – 2000) because of globalization that became the dominant paradigm in economy and policy. The <fall-of-the-wall> unified Eastern and Western European societies favouring concentration of growth and squeezing the market along the lines of Global Apartheid (Amoroso B., Global Apartheid, Economics and Society, Federico Caffè Center, Roskilde, Città di Castello, 2004). Furthermore, the implementation of the new neo-liberal policies put an end to Keynesian economic policies that sustained mass production and consumption during the stage of national capitalism. Therefore the public sector policies and its Public Goods were not needed anymore so their decline started.

Paradoxically these two negative events in the history of European societies are also the cause of the rise of the most innovative events of the new century. The withdrawal of capitalism from vast regions and sectors - because of its concentration on the rich segments of the markets (the capitalist answer to the problem of worldwide sustainability) - left market spaces and social activities uncovered. This has given rise to civil society mobilization that - after a short period of resistance to globalization in defence of the welfare system - decided to experience new ways of economic and institutional organization: the rise of social cooperatives and social enterprises together with a revitalization of local development as the basis for the revival of communities. The slogan of globalization “from global to local” was upturned into its opposite: from local to mondial (worldwide). The first assumes globalization as the model to get inspiration at local level. The local community ought to ADAPT to it. The second oppose to this monocentric view a polycentric one, where it is the sustainability of the single community and its society project that determines the forms and the extension of the necessary dialogue with other communities for the achievement of the Common Good worldwide. Therefore within this new paradigm, the Social Enterprise becomes the answer to the problem of sustainability in the production of goods and services for the new economy.

To sum up what has already been mentioned we can state that the qualifying elements of the Social Enterprise are:

1. Its territorial and local roots as a condition for an efficient choice of sector of activities and use of local resources.

2. Its belonging to the community for the perception of the demand posed to it, as well as for the social and productive impact of the community that it generates.

3. The hybrid character of the resources and labour forms at disposal of the entrepreneurial project, able to make use of all forms of employment beyond the

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boundaries of market oriented juridical definition with reference to employment as well as ownership forms.

4. The involvement of all entrepreneurial actors through real forms of participation and co-decision in the enterprise management.

5. Attention and adequate investments in the inter-organization relations at the local as well enlarged level, able to conjugate local cooperation with cooperation with producers and markets in other communities and other countries.

The Social Enterprise model is naturally inscribed within the frame work of the problems raised by Mondiality.

Access to, and the use of, resources and rights.

The topics of access to, and the use of, have been the key words by which the efficiency of a democratic system has been monitored and measured in European policy as well as in the international organizations during recent years. They have been widely introduced to set up the benchmarking for the processes of democratization. During the period of the welfare state, the procedures for their implementation have been based on the supply by the public sector of the basic infrastructures needed to achieve these goals and by the strategy of “rights” to be guaranteed to all citizens by formal declarations (right to work, right to income, etc.). The strategy of rights has been widely intertwined at international level with the one of “human rights” sharing with it the underestimation of the problem posed in both cases by the “to” and by the “of” assumed, clearly defined and well known.

However some results have been achieved but nearly always below the level of expectation. And since the seventies problems that were finally considered solved - such has poverty, inequality, poor labour conditions, in-security, etc. - have reappeared on a greater scale. These have provoked various reactions from the people and their movements expressing a general disaffection for the institutions and politics as such, and have originated initiatives from institutions and from the civil society. The new slogan has become “participation”, introduced on a vast scale at all levels of institutions and tested also in some sectors of the economy. But the limit of participation is that it does not question the objectives and the forms of the existing political and economic institutions, but tries to create more support to their functioning. It can improve “access to” and “the use of” but does not question the objective and the forms for which participation is intended to work.

This brings us back to the central problem of form and content of the model of development to be chosen. The prevailing trend today, despite the declarations and policies that give attention to the problem of diversity in European development rightly pointed out as a positive and specific European value, is a monocentric one (Eurocentrism and Westernization). Diversity has not become the key to understanding the need of a polycentric development based on regions and communities – where values, objectives and forms are shared but remain different – but as already mentioned going from global to local by a process of adaptation of the latter to the former.
In a short period of three decades, China has moved up from a “third world” country to be a leading second largest industrial nation in the world surpassing Japan. The gap between the first such nation, the United States, and China is still substantially large. But some projections suggest that growing at about 10% annually, China may catch up or even surpass the United States by the middle of this century. The so-called “Chinese Miracle” has, however, not been achieved without serious social and environmental costs. This presentation highlights the following main points and their subsidiaries:

(1) The antecedents and mechanisms that have propelled the “Chinese Miracle.”
(2) The unintended consequences of technoeconomic growth in China.
(3) Lessons of the “Chinese model” for both the developed and the developing countries.

Introduction

This keynote address reviews the status of technology and industrial development and their combined societal impacts in the following four distinct historical epochs in China:

- The Chinese science and technology in the ancient period
- “Revolutionary” science – the age of Mao Zedong, 1949 through 1976
- Deng Xiaoping and the four modernizations, 1980 to the present
- China’s future, and that of the world

The Ancient Period

The Chinese built the 4000 mile Great Wall some 200 years before the birth of Jesus Christ. They invented bureaucracy even earlier, thousands of year before Max Weber brought it to the attention of the western world. Some of the greatest inventions we live by even today came from China; most notable among them being gun powder, paper, paper money, papier-mâché, printing, the viaducts, suspension bridges, the wheel barrow, dams, dykes, the clock, the compass, the kite, astronomical observatories, herbal medicine, acupuncture, moxibustion, and countless other such inventions.
Yet until recently, Chinese contributions to the development of science and technology in the ancient and the medieval periods were largely ignored in the West. Joseph Needham, the renowned British chronicler of history of science in China, once noted the American missionary Wells Williams solemnly and formally declaring that “botany in the scientific sense of the word is wholly unknown to the Chinese.” Needham’s response was equally noteworthy: “Such a statement could only have been made by one of a generation totally ignorant of the history and prehistory of science.”

The ancient wisdom of China had indeed begun to be eclipsed by the turn of the 17th century. The Renaissance, Reformation, and Industrial Revolution were taking shape in Europe along with the age of colonialism. Ironically, the colonial powers used some of the earliest Chinese inventions like gun powder and the compass to dominate the world, including China. They also got the Chinese hooked to opium illegally brought in from Goa and Java via the famous Silk Road.

“Revolutionary” Science in the Age of Mao Zedong, 1949 through 1976

Revolutionary science in China began to take shape along with the Peoples Revolution in 1949. The Chinese Academy of Sciences (CAS) was established in 1949 under the State Council of China – the highest political authority. Prime Minister Nehru’s Science Policy Resolution in India in 1948 and establishment of the Indian Council of Scientific and Industrial Research even earlier (1942) are noteworthy parallels.

Now the Academy has six sections for the development of mathematics and natural sciences in about 100 institutions spread all across China. Its contributions to the development of science and technology were less than meritorious in the early phase of its existence. This was due largely to governmental patronization and lack of interaction with similar agencies abroad, (except with those in the (then) Soviet Union). All technoeconomic interactions with the so-called “Free World” were then banned.

During this period China was noted by the outside world for its political excesses, persecutions, regimentation, and above all, the Great Proletarian Cultural Revolution (GPCR). The GPCR sent millions of scientists and intellectuals into farms and factories to do what Mao called “the people’s work through manual labor.” Brutal as this “revolution” was, it left a legacy of how a nation can mobilize its vast resources for “human centered development” (a la Mahatma Gandhi).

During this period, China created 50,000 Peoples Communes. The greatest organized movement in world history to develop rural technology systems was launched through these communes, 15 years before the publication of Schumacher’s “Small is Beautiful.” The commune-based Great Leap Forward produced the (then) famous barefoot doctors, free rural clinics, thousands of biogas power plants, backyard steel furnaces, mini-hydroelectric dams, systematic use of animal and human refuse as agricultural fertilizers; and many more such small-scale people-centered schemes.

Through these schemes Mao envisioned overtaking the technoeconomic achievements of the West. But the “self-reliant” Leap Forward turned into a colossal fiasco. Collectivization of technology, industry, and society became a peril instead of a
panacea. By 1985 all Communes, and communal life along with them, disappeared from the Chinese landscape. China was about to enter a cataclysmic change.

Notable achievements of “revolutionary science” included: universal healthcare, population control through one-child per family, enhanced agricultural productivity, self-reliant labor intensive technical systems in the rural Communes, massive public housing projects in the cities, free and compulsory education for all, and arguably the detonations of an atomic bomb (1964) followed by an H-bomb (1967) through pirated Soviet knowhow. However, even as late as the 1980s, China remained a technologically backward and generally a very poor country.

Most Chinese during the “revolutionary science” and even much after its demise were deprived of modern means of communication and transport, decent housing with adequate water and power supply, sanitation facilities, discretionary foodstuff, personal possessions, and expendable incomes. Bicycles were the most common means of commuting by the common persons. Crowded trains and rickety buses were used for long distance travel. Personal automobiles were non-existent, even for the top government and party officials who used official cars.

All cars, including government run taxicabs, looked exactly the same – green Soviet era Ladas. Up until the end of the 1980s, computers, fax machines, personal telephones, TVs, and other IT products already commonplace in the advanced industrial societies were generally nonexistent in China. Commercialization of products and services was considered a morally depraved bad bourgeois habit.

**Deng Xiaoping and the Four Modernizations**

Matters began to take a dramatic turn by the early parts of the 1990s in the Chinese social and economic fabrics. China was about to enter the most dramatic scientific and social change, and the world to witness the most dramatic technoeconomic transformation in human history. The Chinese Premier Zhao Enlai had initiated the idea of The Four Modernizations - of agriculture, industry, national defense, and science and technology in 1963, but only to languish until much later.

They started to take shape under the leadership of Deng Xiaoping who took command of China in 1978 following the death of Chairman Mao in 1976. Given the nature of the Chinese political system, when the top leadership decides to change course or implement a scheme, it just gets done, unlike some other countries we all may know well. Deng lifted the Chinese veil of secrecy and isolation through his open door policy. Foreign technology and capital began to flow into China. Market mechanisms were introduced. Business enterprises and agriculture were decentralized.

Following the example set by the Japanese Ministry of International Trade and Industry (MITI) nearly four decades earlier, China began to vigorously divert its substantial R&D infrastructure towards industrial development and export markets. The Chinese Academy of Sciences was given the mandate to launch new industrial enterprises in addition to its traditional research and education functions. Since then, the CAS has invested in or created over 430 science- and technology-based enterprises in eleven industrial sectors, including eight companies listed on world stock exchanges.
The computer giant Lenovo is the most famous of the enterprises floated by the CAS. In 2005 Lenovo bought out the IBM PC division for a paltry sum of less than $2 billion. It is now the fourth largest vendor of personal computers in the world and the largest seller of PCs in China, with a 28.6% market share. Another example of highly successful state owned enterprises is the China National Offshore Oil Corporation (CNOOC) with aggressive oil and gas explorations through joint ventures in Africa and Australia.

Huawei Technologies is a notable example of privately owned IT companies established in 1988. Its worldwide R&D, manufacturing, and marketing operations are located in cities like Stockholm, Dallas, Silicon Valley, Bangalore, Moscow, Jakarta, and Wijchen. Huawei, along with other Chinese companies, is rapidly moving towards software development as well to compete with the other software development Mecca, India.

Shanghai Electric Company recently signed a $10 billion deal to sell power generating equipment to the Indian conglomerate Reliance AD Group. China’s space program is rapidly moving towards landing a Chinese man on the moon. It is also building its first aircraft career. Its automobile and aircraft industries will soon be competitive on a worldwide basis.

Recent Chinese infrastructure developments include modern airports, four lane freeways, and fast train grids connecting this vast country through land routes. The 2006 Qinghai-Tibet Railway connecting Tibet with the mainland runs at 1000-1500 feet altitudes with 100 miles per hour speed. Super computer Tianhe-1A, developed at the National University of Defense Technology, is now the fastest computing machine in the world. It surpasses anything that currently exists even in the United States, including the fast one at Oak Ridge National Laboratory in Tennessee. These developments have serious implications for the modernization of national defense as part of the Four Modernizations. The world has to be mindful of the fact that China is a nuclear power with the largest standing army in the world.

Just about two decades ago, personal telephones were nonexistent in China. You could not easily make an intercity telephone call through the publicly available network either. In contemporary China Mobile phones have grown from 87 million in 2000 to more than 500 million today. Internet is spreading like wildfire with 220 million users, the world’s largest number, surpassing Web surfers in the United States although still a small percentage of the total population.

China has developed secure supply and demand chains with mega superstores like the American Wall-Mart and the British Tesco. About ninety percent of consumer goods including audio and video systems sold at Wall-Mart and other American stores are imported from China. Consequently, China has now surpassed Japan to claim the status of the second largest economy in the world. The gap between the first, the United States, and China is still very large though.

**Lessons for the World**
The questions often discussed in international policy circle these days are:
1. How could China reach the status of a technological superpower and the second largest industrial economy in the world in a short period of three decades or less?
2. What are the lessons others can learn from the Chinese experience of the past 50-60 years?
3. How can they interact and collaborate with China in the matters of science, technology, and industrial development?
4. What lies ahead for the Chinese economy, technology, and society for the next quarter of a century and its global implications?

Here are a few tentative answers to the above questions: China’s time horizons are very long indeed. From Mao to Hu Jintau the Chinese leadership has been conscious of the fact that China is one of the five oldest and great civilizations in world history. Its vision of the future is equally long term - that is to recreate its past glory and become one of the greatest nations again. Brutal as the revolutionary period (1949-1976) was, the foundation for rapid growth through massive mobilization of human and natural resources was laid during that period.

In the context of national development Chinese science and technology policy makers adopted the “technology and industry first, science later” approach early on unlike India’s reverse approach of “science first, technology and industry later.” Chinese R&D expenditure currently runs at 1.5 % of GDP (next to India’s less than one percent) – more than in most EU countries. There are 3000 researchers per million of population involved in technology adoption and adaptation. What is more significant is China’s 6% of GDP expenditure on the development of information/communication technologies (next to India’s 4%).

Others factors also contributed to China’s rapid technoeconomic transformation during the past two decades. As the Four Modernization program began to be earnestly implemented in the 1980s under the leadership Deng Xiaoping, China opened its doors to massive foreign direct investment (FDI) and technology transfer to become a Mecca for offshore manufacturing. Unlike many other developing countries, instead of being perpetually dependent on foreigners the Chinese learned to beat them on their own turf.

**China’s Future, and that of the World**

China is expected to remain a great technoeconomic, and consequently a political power in the foreseeable future. It will be a leader in renewable sources of energy at the same time that it continues to invest heavily at home and abroad in developing conventional energy sources to feed its voracious appetite for them. In addition to heavy investments in renewable energy systems, China will have to get serious about controlling its rapidly deteriorating environment. Poverty, disparity, and corruption may continue to haunt China for a long time. The general standard of living is likely to remain highly uneven for its vast population. Labor unrest and public disenchantment will pose serious problems for the Chinese leadership in the coming years. Due to its one-child-family policy, China’s population is ageing and the number of working age people is rapidly declining. This and the fact of uneven industrialization continue to cause massive rural to urban migration as a highly destabilizing force.

In the context of economic globalization, the center of gravity for offshore manufacturing and FDI will move away from China to other less developed countries due to increasing labor unrest and wage increases. Some of the American manufacturing in
China is likely to return home. Technology transfer between India, China, and the other developing countries in Asia, Africa, and Latin America will increase considerably and pose serious challenges to European and American economies. China, India, Russia, South-east Asia, maybe even Japan are very likely to become a “common market” of sorts. Their combined industrial infrastructure, software development capacity, and vast markets and qualified manpower are most likely to turn the twenty-first century into the “Asian Century.”

Finally, there are two other paramount lessons that both the developed and the developing countries can learn from the Chinese experience: that (1) single-minded determination to put national plans into practice, rather than getting bogged down in internal and external conflicts, may be a surer way to ensure peace and prosperity at home and abroad; (2) technoeconomic development at the cost of human and environmental welfare may not be in the best long term interest of the global society.
A framework for the current state of understanding of technology entrepreneurship capability

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Abstract

Technology entrepreneurship, a relatively new term is receiving increasing recognition from the scholars of various streams of business and science and technology disciplines, as well as from the industry players and business men. Technology entrepreneurship is indeed becoming vital in the current globalization and liberalization economy as it provides greater opportunities and enables effective optimization of resources to attain high profit margins. This paper presents theoretical framework for understanding technology entrepreneurship capability using Shane and Venkataraman (2003) definition of technology entrepreneurship and an improvised innovation capability audit tool as introduced by Bessant et al. (2000) and promoted by the World Bank. The improvised technology entrepreneurship capability framework is analysed through the lens of entrepreneurship and innovation, specifically according to eight key dimensions of technology entrepreneurship identified from the four technology entrepreneurship factors: awareness and search from the context factor; strategy and core competency from the firm factor; technology paradigm and linkages from the technology factor; and learning and leadership from the entrepreneur factor. This study believes that the proposed framework adds to the existing literature of entrepreneurship and innovation.

Keywords: Entrepreneurship, Technology, Innovation, Technology Entrepreneurship, Technology Entrepreneurship Capability

1. Introduction

Technology entrepreneurship is basically the merge of two words from two disciplines: technology from the innovation discipline and entrepreneurship from the business discipline. Technology entrepreneurship is thus understood in this study as the integration of technological and entrepreneurial realms. Technology entrepreneur then is described as individual who carries out entrepreneurial activities that are technology oriented. Hence, technology entrepreneurship capability is referred to as the capabilities of a technology entrepreneur, specifically the knowledge and skills required by the entrepreneur to carry out technology based entrepreneurial activities successfully.

Having defined the relevant terms, this paper continues with a discussion on the different fields of study involved, or in other words, the two inter-related disciplines, namely entrepreneurship and innovation. A review on the pertinent literature covering the major issues emanating from the innovation discussion, notably technology and technology capability are presented. Consequently, the fourth part presents the framework for the emerging field of technology entrepreneurship capability, followed by a brief summary in the final part of the paper.
2. Literature Review

This section provides a review of relevant literature that is pertinent to this study; the main themes include entrepreneurship and innovation.

2.1 Entrepreneurship

An enormous collection of literature exists in the field of entrepreneurship; it has been dealt with extensively by numerous scholars from various disciplines such as sociology, psychology, and economics. On the relation to personality traits, behavior, social and environmental influences, Weber (1930) is among the early authors who have discussed entrepreneurship in terms of behavior where a value system is regarded as essential to an entrepreneur’s behavior.

McClelland (1961; 1971) explored psychology to explain an individual’s need for achievement as the motivational factor that led entrepreneurs to perform better. Chandler and Redlick (1961) recognized skills and motivation as factors towards achieving entrepreneurial success. According to Johnson (2001) entrepreneurial behavior also refers to openness to new information and people, motivation, and making independent and self-directed decisions. A study by Filion (1997) associated entrepreneurs with environment; for instance, entrepreneurs are regarded as a reflection of the characteristics of a period and place that they are accommodated (McGuire, 1964, 1976; Toulouse, 1979; Newman, 1981; Gibb and Ritchie, 1981; Ellis, 1983; Filion, 1991; Julien and Marchesnay, 1996).

From the standpoint of economics, there are a number of authors who associate entrepreneurship with innovation. The pioneers in this field such as Cantillon (1755) and Say (1803) viewed entrepreneurship as a risk-taking activity. Subsequently, Schumpeter (1928) introduced a new notion to the field of entrepreneurship, namely “innovation”. He viewed entrepreneurship as a dynamic process of creative destruction, in which he put forward the idea of innovation that changes the basic technological and demand parameters of the economy (Schumpeter, 1943).

2.2 Innovation

Innovation is defined by Schumpeter (1950) as the creation, development and introduction of new products, processes, systems and organizational forms. Schumpeter (1939) treats innovation activity as an internal factor in economic change. His theory of economic change on the role of innovation and the entrepreneur was outlined in the ‘Theory of Economic Development (Schumpeter, 1934)’.

In this book, Schumpeter (1934) identified five ways of revolutionizing the pattern of production, that is, the introduction of a new product to the consumers, the introduction of a new production method, the exploitation of a new market, the utilization of a new source of supply of raw materials or partly manufactured goods, and the implementation of a new way of organization.

Thus, in undertaking an innovative endeavor, a great deal of information is needed on a variety of subjects such as the market situation, new technological developments, sources of technical assistance, government promotional measures, etc. (Rothwell and Zegveld, 1982). Among these various subjects, technology is regarded as one of the crucial components in an innovation activity; technology has often been
perceived as a function of innovation in creating new things and in matching it with market needs. Indeed, the focus on technology as a significant factor in Schumpeter’s notion of innovation is also emphasized by other scholars (Freeman, 1998). Freeman recognized that innovation is developed from technology and an outcome of new scientific results.

2.2.1 Technology

Technology is defined as the ability to carry out productive transformation, and includes the ability to act, and a competence to perform; technology transforms materials, energy and information from one state to another value-added state (Metcalfe, 1995). Twiss and Goodridge (1989) viewed technology as a powerful resource in gaining competitive advantage. Schumpeter’s theory of economic development reflects that technology is driven by entrepreneurs, and it is the entrepreneur who plays a major role in creating inventions through the appropriate implementation of technology (Schumpeter, 1912).

In addition, Dopfer (1992) defined technology as an engine of growth, and its application is seen in the branch of Neo-Schumpeterian research like Technological Paradigm (Dosi, 1988), “focusing devices” (Rosenberg, 1976), “Technological Trajectory” (Nelson and Winter, 1977), and others.

Technology has been considered as knowledge, as skills and as artifacts by Layton (1974). In this respect, technology is deemed to have its own specific framework of concepts, ideas and relationships within which it develops over time, and that this framework is reflected in a division of innovative expertise between the various institutions which support that technology (Constant, 1980; Laudan, 1984; Vincenti, 1990).

These studies clearly show that technology carries a comprehensive definition which is understood as ‘a body of knowledge, tool and techniques, derived from both science and practical experience that is used in the development, design, production and application of products, processes, systems, and services’ (Abetti, 1989). For the purpose of this study, technology is essentially viewed as the tool that enables the entrepreneurial activities to be carried out effectively.

2.2.2 Technology Capability

As technology has become increasingly important in this era of globalization, the concern then is on acquiring technological capability to achieve competitiveness. UNIDO (1986) looked at technological capability as the ability to train manpower, ability to carry out basic research, ability for testing basic facilities, ability to acquire and adapt technologies, and ability to provide information support and networking. The World Bank (1985) has categorized technological capability into three independent capabilities: production capability which consists of production management, production engineering, maintenance of capital equipment, and marketing of produced output; investment capability which consists of project management, project engineering, procurement capabilities, and manpower training; and innovation capability which creates and carries new technical possibilities for profit-making purpose.
Besides the definitions above, there is another study that categorized technological capability into six major areas: production capability, investment capability, minor change capability, marketing capability, linkage capability and major change capability (Ernst et al., 1998). Lall (1990) defined technological capability as the required human skills such as entrepreneurial, managerial and technical to set up and operate industries efficiently; there are two levels of technological capabilities identified: firm and national.

At firm level, Lall (1990) noted the requirement for three types of capabilities; namely entrepreneurial, managerial and technological capabilities. In terms of technological capabilities, he identified three elements: investment, production and linkages. Investment capabilities involve the skills required to utilize the invested resources effectively; production capabilities include all the necessary skills required to carry out the product, process and industrial engineering activities; and linkages capabilities as the skills necessary for transferring knowledge and technology infrastructure. Meanwhile, at national level, Lall (1990) referred to the incentives provided, supply of skills, and efforts to master, adapt and improve technologies, and institutions to support market functions.

Thus, it is hoped that the elucidation of various definitions and different classifications of technological capabilities as presented above provide valuable insights into the major theme of this study, and simultaneously pave the way for a better understanding of the significant terms applied in this study, namely technology entrepreneurship and technology entrepreneurship capability.

3. Methodology

In drawing the technology entrepreneurship capability framework, the Shane and Venkataraman definition of technology entrepreneurship and the World Bank framework was applied to this study. The framework introduced by Bessant et al. (2000) was improvised according to the research context in order to meet the objectives of this study. Eight key technology entrepreneurship activities were identified based on the four constituencies of technology entrepreneurship as highlighted by Shane and Venkataraman (2003) in their special issue on technology entrepreneurship, which includes industry, firm, technology and entrepreneur. However, the term ‘industry’ is replaced with ‘context’ as it is regarded more suitable in this study.

The 8 key dimensions of technology entrepreneurship are: awareness, search, strategy, core competency, technology paradigm, linkages, learning, and leadership. ‘Awareness’ is referred to as the ability to recognize pertinent environmental changes, and the need to improve; ‘search’ as the ability to explore for opportunities and threat; strategy as the plan of action to achieve the envisioned goals that are significant for the economic growth of the firm; core competency as the economic strength of the firm that needs to be identified and built upon; technology paradigm as the ability to understand the existing platform of technology; linkages as any form of collaborative effort established by the firm; learning is the firm’s effort to encourage acquisition of codified and tacit knowledge on continuous basis; and finally leadership as the ability of the entrepreneur to lead his firm to achieve competitive advantage and sustain it.
4. Technology Entrepreneurship Capability

This study is among the few studies to discuss the emerging discipline, notably the issue of technology entrepreneurship capability. Technology entrepreneurship capability is simply understood as the capabilities of the four factors of technology entrepreneurship that are: entrepreneur, firm, technology and context.

As in conventional entrepreneurship literature, the entrepreneur is of concern in this study as the person who navigates the direction of the firm. He should be equipped with adequate knowledge and apply it in his entrepreneurial endeavor. The entrepreneur should also have the capability to implement the knowledge possessed appropriately, for instance, in problem-solving activity. The entrepreneur has to be agile which means that he should act quickly and smartly.

The generic term ‘firm’ is used in this research as applied in the Oslo Manual guidelines. Accordingly, “a firm can make many types of changes in its methods of work, its use of factors of production and its types of output which improve its productivity and, or commercial performance” (OECD, 2005). The firm factor includes all the firm’s functions such as management, finance, and human resource. These functions need to be managed effectively for the success of the firm. As such, the entrepreneur should have the capability to develop strategies that can bind the firm’s functions effectively so as to sustain high growth performance.

Technology is part of environment as suggested by Porter (1990) but in this study technology is regarded as an independent factor due to its significance in the technology entrepreneurship term. Furthermore, in the discussion on technology entrepreneurship termed by Shane and Venkataraman (2003), the technology element has been discussed extensively and not inclusively in the environment factor. This is basically due to its significance in innovation and related activities, which constitutes the driving force towards achieving sustainable competitive advantage. Therefore, it is essential for the entrepreneur to have the capability of applying the technology to exploit opportunities effectively in his industrial environment.

The context factor is of concern in order to know the industrial environment in which the entrepreneurial activity is carried out. Usually, environment that is conducive leads to the success of the firm; so, it is essential for the entrepreneur to have the ability to understand the industrial environment, and the changes that are taking place in order to take actions deemed appropriate. The four technology entrepreneurship factors: entrepreneur, firm, technology and context are inter-related and they complement each other.

Technology entrepreneurship capability is thus referred to the variety of capabilities that a technology entrepreneur requires to create competitive advantage, and to sustain firm performance that includes the capabilities to recognize environmental changes and market trend; continuously search for opportunities; effectively structure strategies; develop core competencies; establish strategic linkages; understands the technology paradigm of the industry; possess codified and tacit knowledge of particular
technologies; and practice leadership quality to affect favorably and effectively the operation and management functions of a firm for sustainable performance motivation.

**Conclusion**

Technology entrepreneurship is a relatively new field of study; as such, there is relatively limited literature in this discipline, notably in Malaysia. Therefore, this study has made an attempt to explore this emerging topic to add to the limited literature in this relatively unexplored field of study. To facilitate a better understanding of this new discipline, relevant terms such as entrepreneurship, innovation and technology have been defined prior to explaining the main term in this study, as technology entrepreneurship.

In traditional literature on entrepreneurship, the emphasis is on the entrepreneur, including his personality traits, behavior, and social and environmental influences, or rather the concentration of entrepreneurship literature which is ‘person-centric’. It was Schumpeter (1928), who introduced a new idea in the entrepreneurship discipline, which is innovation. He added a new attribute to the term ‘entrepreneur’, and was able to change the basic parameters of entrepreneurship. Schumpeter’s entrepreneur is one who has technical knowledge and is held responsible for applying it; the entrepreneur is not merely an inventor but one who is responsible for bringing the innovation to the market to achieve competitive advantage. Following his notion, this study defines technology entrepreneur as one who has the capability to acquire knowledge and entrepreneurial skill and apply them for a firm’s sustainable performance. Hence, technology entrepreneurship capability includes the capabilities of not only the entrepreneur, but also the firm, technology and context.

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Challenges and opportunities for renewable technologies in the Arabian Gulf

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Renewable technologies are becoming internationally recognised as a vital contribution towards a sustainable energy future. An instructive case to consider is that of the principal oil superpower, the Kingdom of Saudi Arabia and the Arabian Gulf region. With at least a quarter of the world’s proven oil reserves, it is also an increasingly urbanised and industrialised region that is blessed with abundant solar radiation and a reasonable wind resource. Nevertheless, despite several tentative undertakings in the field of renewables since the 1970s, its massive renewable energy resources have not yet been sufficiently exploited (Al-Saleh, 2007). A substantial number of ‘energy scenarios’ have been developed around the world in order to provide a framework for the systematic exploration of energy perspectives and their potential implications. Many of these scenarios are quite often developed by means of the Delphi technique, where the aim is to identify future opportunities and challenges so that better-informed action can be taken today. Since energy infrastructure usually takes a very long time to build, most of the energy scenarios tend to adopt a very long-term perspective, typically looking ahead 30 to 50 years (Harmin et al, 2007). The Delphi technique is an expert-based method of eliciting, collating and refining anonymous group judgements on a complex subject typically through circulating a number of sequential questionnaires (Loveridge, 1999).

This paper reports a snapshot of findings from a doctoral research study completed at the University of Manchester in 2010 by Yasser Al-Saleh (supervised by Dr. K. Malik and Dr. P. Upham). Part of the study utilised a Delphi panel comprising of 35 members, including some international experts on the subject, as well as highly informed specialists and stakeholders (academics and industry managers), mainly from Saudi Arabia and other Gulf nations. Some of the participants (Saudi officials) did not wish to disclose their names due to the sensitive nature of the subject of alternative energy in a major oil producing economy. The Delphi part of the study lasted seven months comprising three formal rounds as well as other informal communications between the rounds. The three rounds started by asking the Delphi panellists to comment on (and justify where possible) whether or not they personally believed that renewable technologies would have a major role to play in Saudi Arabia by 2050? Further rounds reported on results of first round and the last round configured participant views along with an extensive literature review to form a prototype set of scenarios for renewable energy supply in the Gulf region (particularly Saudi Arabia) through to 2050. These prototypes were subsequently made available to the panellists for further scrutiny and feedback (Al-Saleh et al, 2008).

In this Delphi study, the factors that have consistently emerged as being both highly uncertain and very significant with respect to future renewables in the Gulf region are:
• The availability of fossil fuels (in the Gulf region):

Saudi oil reserves make up around 25% of the world’s proven reserves and some experts suggest that Saudi oil production has already peaked, while others maintain that this peak in production is still far away in the future. Hence the Delphi team see this factor as being one of the most significant and uncertain when considering the prospects of renewable technologies.

• Actions on environmental protection (in the Gulf and globally):

Whilst a number of environmental concerns were expressed with regard to the continual reliance on fossil fuels, the issue of global warming received most of the attention amongst the majority of the panel. Although three of the panellists admitted their utter disbelief regarding the phenomenon of global warming, and argued that no country should sacrifice its economic and industrial growth for the sake of reducing carbon dioxide (CO$_2$) emissions.

• Choice of renewable energy technologies:

The mainstream view of the panellists did not consider nuclear power, not just because it is not a renewable source of energy, but mainly owing to the existence of some regional political reasons for it to be avoided. Throughout the Delphi study, solar photovoltaics (PV), wind power and solar thermal power have emerged as the most preferred technology options in the case of the Gulf region.

Our findings showed that all scenarios are developed on the assumption that the Gulf countries (especially Saudi Arabia) are mainly going to rely on imported foreign renewable technologies to begin with (say until 2025) and then will consider indigenous development further down the line (around 2025 to 2050). Suggested factors that could contribute towards the successful establishment of indigenous renewable energy industries in the case of Saudi Arabia include:

- political support especially in any monarchy, where authorities have considerable power and financial resources;
- move towards a more participatory system of governance and less bureaucracy;
- strengthening the national educational system and providing more vocational training;
- enhancing the linkages between Saudi universities and industry;
- allocating higher budgets to support science and technology, as well as widening R&D activity in both public and private sectors;
- acquiring equity stake in international companies which conduct relevant R&D;
- increasing the role of the private sector in electricity and water projects;
- developing a culture of patenting and entrepreneurship in the country;
- rewarding innovators and researchers in relevant fields;
- setting-up more international technology transfer joint venture programmes;
- provide inward investment opportunities for renewable energy technology firms.

Having mentioned the context within which the scenarios will operate and the factors that are considered common to most scenarios, it is now appropriate to present the renewable energy scenarios using the example of Saudi Arabia. These scenarios represent stories about the future where each narrative is designed to be read and explored on its own, considering all the scenarios will help to establish a better appreciation of a wide range of different energy futures in the context of Saudi Arabia in particular and the Gulf region more widely. Here are the potential scenarios for Saudi Arabia:

**Blue scenario:** This would represent a continuation of the current trends in terms of the abundant availability of fossil fuels and limited strategic actions on environmental protection. There is some consideration for the renewable option of Solar Photovoltaics. However with continuation of fossil fuel trend the country could choose to maximise its oil production and perhaps further expand its operations in the Far East in order to achieve a maximum market share and ultimately become the world’s unsurpassed supplier. This could result in a drop of oil price to as low as $10 per barrel, which would guarantee the maintenance of reasonable revenue to Saudi, whose production costs are very low. Such an approach may also result in driving other high-cost oil producers (including OPEC members) from the market, as well as demolishing much of the global interest and research into alternative energy means.

**Yellow scenario:** Here global environmental concerns become significantly stronger and environmental actions become more coordinated. For example carbon capture and storage has become a widely-adopted technology and there is strong market growth in hydrogen fuels for transport applications. Solar thermal technologies can be seen as an attractive choice worth considering in this scenario, where countries in the Gulf region are blessed with very high levels of direct solar radiation, but increasingly face an increased demand for electricity and water.

**Red scenario:** This scenario is characterised by rapidly-dwindling oil reserves combined with carelessness towards the tackling of environmental issues. There is lack of commitment to reducing CO₂ with only a few residual emission trading schemes. In a world of scarce oil reserves, Saudi Arabia could decide to dramatically cut its oil production in order to economic advantage of the resulting skyrocketing oil prices. With high oil prices and the non-existence of a carbon-constrained world, the development of tar sands and Coal-to-Liquid (CTL) could become viable (although not of great significance). Also high oil prices might motivate research into alternative energy sources and thereby boost the global prospects for renewables, which are not being sufficiently encouraged by environmental arguments today. Given the huge land area and its
reasonable wind resources, Saudi Arabia could contemplate the option of wind power in order to boost the share of renewables in the country energy mix.

**Green scenario:** The green scenario shares with red scenario the limited availability of fossil fuels. The global concerns of greenhouse gas emissions would become the subject of intense negotiations and strict international agreements. This would consequently enhance the viability of renewables and non-fossil energy means (including nuclear power) around the world. Moreover, hydrogen and biofuels would become widely used as transport fuels. Saudi Arabia could then pursue renewable energy technologies (i.e. solar thermal, solar PV and wind power) in order to meet rising domestic needs for electricity and water production. With regards to its remaining oil reserves, Saudi might decide to cut production and oil sales in order to stretch the lifetime of its most precious export and further expand its energy-intensive industrial capabilities. Consequently, the availability of a continuous flow of cheap fossil fuels into international markets would become increasingly threatened forcing Oil importers to act independently to enhance their energy security in order to avoid increased greenhouse gas emissions.

Finally, we would stress that a transition towards sustainable energy systems would essentially involve “innovation” leading to more sustainable technological and institutional processes. This requires not only innovation in the context of R&D for renewable technologies, but in the policy-making arena with more policies geared towards linking innovation to sustainable development for example. This relates to institutional reforms as well where innovation needs to be high on the agenda of Government ministries who need to have a joined-up approach to promote innovation. Renewable energy technologies, in general, also need to be regarded as a strategic option and a supplementary – as opposed to an alternative – source of energy in Saudi Arabia. In fact, what would really help in terms of both enhancing the legitimacy of renewables and facilitating a point of departure away from oil is the emergence of a new, and most probably young and highly-educated, ‘pro-renewables’ generation of the Royal Family. Such a new generation could act as ‘system builders’, i.e. a set of actors who are politically and financially powerful enough to alter the existing political economy (and the organisation of power within the Saudi energy sector), and ultimately promote the development and successful diffusion of renewable energy technologies in Saudi Arabia. There is no doubt that these key actors cannot function in isolation, as they will, for example, need to team up with renewables-orientated entrepreneurs and investors who are keen to transform innovative energy possibilities into business opportunities.

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Going From Local to Global: Solving Local Problems - Inserting Into Global Science

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Abstract

In a world that is in perpetual flux, we observe new ways of doing science, new purposes for the development of technology, and new impetus and organization for innovation. Countries that traditionally have been behind in the production of science are now in the forefront, particularly from South Asia and South East Asia. New inter-disciplines and trans-disciplines consolidate by their own right. New opportunities evolve for scientific development of Third World countries. New means for information interchange open unexpected opportunities for collaboration between the countries that “have” and those that “have not”, between their respective scientists, and between scientists and other social actors in a myriad of new fora outside the traditional channels of academic exchange. New “invisible colleges” (Wagner, 2008), connecting scientists both North-South and South-South emerge. The world’s arrival to the era of knowledge is changing the role of science and technology in society. Some current trends point out to the production of knowledge linked to fulfill the needs of a global market, somehow described by Gibbons and associates (Gibbons et al., 1994; Nowotny et al., 2003, 2005) as a new mode of knowledge production called ‘Mode 2’. It claims to be “more socially accountable” than the traditional way of doing science, identified as ‘Mode 1’. However, in the past years new forms of doing research have appeared in some countries that do not correspond to this trend. Although they share some characteristics of ‘Mode 2’, they differ drastically in the sense that they are actually more socially accountable (Jiménez, 2004, 2007, 2009; Jiménez and Escalante, 2007). These forms respond to current local or regional problems and opportunities, dissociated with global markets, hence making science really more socially accountable. A new model of learning gearing to research in a Latin American country is described. The Center for Innovation and Educational Development (Centro para la Innovación y Desarrollo Educativo, CIDE, 2003), features learning by problem-solving, individual and group study, individualized study plans, and intensive use of Internet, in an environment with no physical installations nor laboratories. Once the students identify their local or regional research problem they wish to work on, they try to contact leading scientists, with specific requests, using the information and communication technologies. The interaction with these top scientists often leads to collaboration and participation in international conferences, gradually introducing them into mainstream science. By the time students defend their doctoral dissertations their involvement in international scientific networks is a reality. The
conclusion is that some segments of society, in congruence with ‘the spirit of Budapest’ (Mayor, 1999; World Conference on Science, 1999a & b), are concerned with local or regional problems and opportunities that can be solved with scientific research. India, having similar characteristics in their needs for research geared to solve local/regional problems as Mexico, is a target to seek similar academic enterprises as the one presented here. These projects are putting in practice alternative models of doing science with emphasis in social accountability, opposite to “Mode 2” tendency. This type of knowledge generation is called ‘Mode 3’ (Jiménez, 2008).

Introduction

In a world that is in continuous change, we observe new ways of scientific cooperation, new purposes for developing S&T, new impetus and organization for research innovation. Countries traditionally behind in the production of knowledge are now at the forefront, such as China, South Korea and to a lesser extent India. With the advent of the new ICT’s alternative opportunities arise for scientific development in Third World countries such as those in Asia, Africa and Latin America.

New “invisible colleges” connect scientists both North-South and South-South, enhancing research interests across hemispheres. Some new research is responding to current local or regional problems and opportunities in less developed countries. Since it is research responding to “bottom-up” initiatives, is dissociated from what global markets demand, thus making science more socially accountable and responsible.

CIDE is a clear example of a social entrepreneurial effort, as it constitutes a case of the emergence of collective dynamism, which is one of complexity theory’s main objects of inquiry in the social sciences. CIDE brings into the scientific community those who wouldn’t normally have the opportunity to participate. This model responds to the fact that, according to their founders and animators, Mexico needs more scientists, especially those that can contribute in the earth and life sciences. This entrepreneurial model focuses its efforts on the provinces, drawing individuals into the scientific decision-making process of what ought to be done in order to solve problems through scientific research. Indeed, in CIDE we see all the tell-tale signs of complexity in the emergence of this social-academic network where cooperation is the dominant value that results in individual empowerment and community betterment through the attainment of graduate degrees by doing research on locally-felt demands and needs. This paper will focus on the model’s founding motivation, its core methodological and epistemological foundations, its attractiveness for new students, and some of its recent results.

CIDE has no physical infrastructure. Professor-advisors do not receive a salary. Students and advisors meet once a month for two full days to socialize knowledge and advance the students’ projects. Students usually already teach full time in educational institutions. CIDE attracts students that are unable, for different reasons (age, workload, family obligations), to join a conventional Ph D program. This situation leads to the formulation of Individualized programs.

Creation and objectives

Dr. Miguel Arenas, from the Autonomous Metropolitan University - Xochimilco (UAM-X), CIDE’s founder and intellectual author, and a group of established researchers
with more than two decades of experience in innovative educational methods, became aware of the need to break with traditional models of higher and graduate education, and of the need to create regional research centers that truly responded to regional needs (López-Pérez, 2004).

The innovative idea of CIDE was thus born out of the recognition that the demand for higher education for the first 20 years of the 21st century will not be satisfied via traditional educational systems. Its members acted upon this reality and designed an innovative educational model. The members asserted that their system “is based on advances in cognitive sciences, which demonstrate that learning is accomplished – especially when referring to higher abilities and elevated levels of domination – when the emphasis is changed from teaching to learning, based on personal and group study carried out by the students” (CIDE, 2003), concentrating on specific topics of research. The individual learns to do research as part of a general process of learning. The model combines: Learning based on problems, self-study as well as group-study, flexible curriculum, intensive use of ICT’s, and the acquisition of generic competencies for research.

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A basic methodological principle that CIDE’s authors encourage in students, is the use of powerful Internet search engines to retrieve scientific information that is at the frontier of knowledge, with the aim of guaranteeing that their proposals and actions are firmly based on facts reported in the current, highly visible literature.

The Center started as an educational experiment between UAM-X located in Mexico City, and the University of Colima, in the Colima State, in 1982. Since then, CIDE experienced a long period of instability, because established scholars see it as a threat to the “status quo” of formal education. Along the years, the model has been accepted by different high education public institutions and after a while, rejected.

Recently, CIDE has reached a period of stability by associating with the “Justo Sierra Studies Center” (Centro de Estudios Justo Sierra, CEJUS), in the State of Sinaloa mountain range, in 2005. CEJUS is another alternative educational experience that has been in function for more than 35 years. Although CEJUS is located within the “Golden Triangle” bounds, it has survived and produced notable results for many years. The “Golden Triangle” is a geographic area in the boundaries of the states of Sinaloa, Durango and Chihuahua, considered a zone of production and distribution of drugs. CEJUS became the central node of CIDE.

CIDE’s explicit objectives in the production of knowledge are the following (CIDE, 2003):

- To develop an innovative model of research where projects are linked to social needs.
- To reach an internationally competitive level in the results of research through scientific production in visible publications.
- To produce reliable, precise and repeatable research results with scientific relevance, within the limits set by measuring standards.
- To promote inter-institutional agreements that will make achievements of institutional educational objectives possible.
- To produce scientific knowledge that will aid national development by the search for solutions to the problems related to the biological environment.

The Model’s main features

The CIDE model is an eclectic amalgam of several advanced proposals that emerge from innovative, new, and alternative education, which have seen manifestation in the concepts of open education, teaching at a distance, and problem-based learning (PBL, cf. T.J. Fenwick and J. Parsons, 1997). CIDE combines the best of these concepts, in addition to the acquisition of generic competencies.\(^{55}\)

The Center brings together all three of the above methodologies in a unique combination that aims to educate students to learn, by doing research, on specific topics and problems perceived by the students themselves in their local communities. CIDE is an attractive educational alternative for students, who are not as comfortable following conventional education or whose age and occupation does not allow them to engage in a formal graduate program.

CIDE offers students an educational experience geared to the acquisition of a higher degree, mainly in the earth and life sciences based on applied research. This opportunity allows them to complete their studies unlike those who for different reasons have not, and then be in a position to start or enhance their scientific careers. Students work from their home, place of work, or wherever they can find a space to fulfill their experiments and/or their “advancement markers.”\(^{56}\)

CIDE has branches in different parts of Mexico. They work with relative independence from each other and from the central node in CEJUS. The Center, like Weick’s loosely-coupled organizations\(^ {57}\), is unique in that there are no hierarchical

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\(^{55}\) Generic competencies are those attributes CIDE has determined an individual who wishes to develop professionally as a researcher should have, as they are generic to researchers throughout the world. Among them are writing, social capital and network-building, full competence in reading and writing in the English language, laboratory skills, electronic search skills, etc.

\(^{56}\) “Products”, as named by CIDE. These consist of experimentation reports and briefs, bibliographic reviews and essays, which are required from students, as per a previously agreed-upon program, that constitute “proof” of his/her research capabilities.

\(^{57}\) The notion of loosely coupled organizations in Weick (1976) refers to those organizations that present a rather horizontal disposition among the different elements, where neither the chain-of-command nor the nature of the relationships is clearly defined. They normally consist of a number of units, departments, offices, which are inter-linked and responsive between them, but that retain a degree of identity and autonomy, maintaining singular characteristics and forms of self-government. This type of organization is more seen in educational systems.
relations or clear command linkages between any of the members, students or staff. The only linkage between students and the organization is high motivation to meet their self-established goals.

Figure 1 shows the linkages between all CIDE nodes, meaning no formal structure, but rather a horizontal hierarchy or hetero-hierarchy. CEJUS currently plays the role of the main node, whereas Topolobampo, Guasave, Culiacán, Angostura, Compostela, and Torreón are interlinked nodes at the same hierarchical level.

![Figure 1. CIDE as a loosely-coupled organization.](image)

The learning process is activated in the socialization of knowledge among professor-advisors and students, taking place in any physical space that allows the meeting of all its members: professor-advisors and students, as well as collaborators and visitors. The process is realized under conditions that encourage the dissemination and communication of ideas and the construction of concepts, hypothesis, theories and objectives.

The above implies that the effective work time, carried out by students individually, is what determines the presence and firmness of attributes (i.e. generic competences) that characterize a scientific worker. The pace of learning will therefore be a function of the time invested in academic work, and is not subject to the traditional academic calendar. Socializing knowledge is where students have the opportunity to publicly air what they have worked on and learned from one socialization meeting to the next.

The socialization of knowledge is a most important part of the model. In contrast to the Open University (Torres Barreto, 2006 and Cookson, 2002), where exchanges on academic aspects of students’ work is essentially a dialogue with their tutor, students here have the opportunity to present advances, air doubts and pose questions, not only before
their tutor, but also before other students with various levels of advancement of their respective agendas. At the same time, they receive feedback from participants of the meeting that wish to contribute, complement, or aid in solving inquiries, based on their own experiences.

The socialization of knowledge takes place in monthly meetings, which are attended by students of each region (currently, CIDE has six regional communities in the Northern part of the country). Figure 1 shows the area of influence of CIDE.

Figure 1. It shows the current area of influence of CIDE, mainly in the Northwest region of the country.

The meetings occur normally in facilities provided by host institutions that are normally the place of work of a professor and/or a student. They are two intense workdays of 10 to 12 hours each. The meetings are composed of students, professor-advisors and observers. A considerable part of the meeting consists of discussions
concerning the methods of study and of research, which vary depending on the level of studies or degree to which students aspire.

Professor-advisors play a very important role in the academic life of students. Through their advice they orient students to fulfill the activities that allow them to learn and demonstrate the attributes that identify them as Doctor of Sciences. As part of the evaluation process, professor-advisors certify the students’ scientific formation, validating the fulfillment of those activities.

The method of study is geared to have students learn by focusing on a specific research project, where they concentrate on learning what is deemed necessary to carry out their research. As they do this, students gradually obtain the generic competencies required for each level of studies.

When the students have not identified a scientific problem they are interested in, and express only an area of interest, they construct an object of study via a search in large data bases with the aid of bibliometric tools, identifying the topics at the frontier of knowledge within an area of motivation. From here, students select a number of articles, placing special emphasis on review articles. The review articles provide the “state of the art”, a synthesis of the most recent and relevant research in the area of their interest.

To guarantee that students are “tapping” the frontier of knowledge, the search is focus on publications that are indexed in the Science Citation Index (SCI), and only those with the highest impact factor are revised by the students.

A second step, still in the construction of the object of study, consists of carrying out what CIDE denotes as “macro-reading” and “horizontal reading” of the texts. Horizontal reading consists of placing side by side the selected articles and inspecting the different parts of each with the aim of detecting regularities or repetitions. In the title, introduction, and references, ‘macro-reading’ identifies “keywords” that denote specific objects of research, objects of study, concrete experiments. On the one hand, this provides an idea of the most current objects of study in the specialized literature, and on the other, it identifies leaders on a specific object of research. This is detected by a simple rate of most cited authors within those articles.

“Macro-reading”, for its part, consists in carrying out a more precise inspection of the original articles selected and the leaders in the field, once the “hottest” objects of study are identified, with the aim of extracting the essential part of the object of study selected by students. That is, without reading the entire article, identify in the introduction what is said about a fact, and what the article proposes to do. Subsequently, students go to the part that contains the development of what is proposed in the introduction and extracts the work’s conclusion, thus contributing to their own work.

Once students are armed with this information, they proceed to conduct their experiments, as required for attaining the bachelors’ degree. For the master’s degree, they apply a proven experiment to a local problem, and for the doctoral degree, they contribute with knowledge that emanates from a local problem that had not been contemplated in the relevant, current specialized literature.
Utilizing the most advanced electronic means in support of students’ research activities is a notable feature of CIDE. Standing out among these is EndNote®, a system for the administration of bibliographic resources that considerably speeds up the search and construction of bibliographic references. With the support of this program, students have access to the largest databases related to academic information, which are accessed by keyword, author, or title of the article. In addition, the program builds a file of bibliographic references for future use, which is automatically realized. The program produces a list of the most cited authors on a particular topic.

With the use of this technology, students have been able to establish the “hottest” topics, even with material that has not yet seen publication (articles that are accepted for future publication). Since the program’s database includes authors’ personal data, students are able to establish personal contact with leaders of various fields, thus generating their own “network of experts”. One of the advantages of such contact is the possibility of obtaining reprints at no cost. Some students have even gone as far as collaborating with the respective leaders in their field of study.

**Going from local to global**

Since its association with CEJUS, CIDE has granted seven doctoral degrees in fields that stand out for their quality at the forefront of biological, medical, and innovative applied technologies. Table 1 shows the examination date, name, age, and sector of work of the graduates. The average age of graduates is 48 years, showing that these are not ordinary Ph D students, but persons who, after engaging in professional work, decided to go for the degree and made an extraordinary effort to achieve their objectives. Likewise, 86% of the graduates work in the public sector.

Table 1. CIDE Ph D graduates since its association with CEJUS.

<table>
<thead>
<tr>
<th>EXAMINATION DATE</th>
<th>NAME</th>
<th>AGE (YEARS)</th>
<th>PLACE OF WORK</th>
</tr>
</thead>
<tbody>
<tr>
<td>JULY/2008</td>
<td>ROCÍO GONZÁLEZ</td>
<td>48</td>
<td>PUBLIC HEALTH INST.</td>
</tr>
<tr>
<td>JULY/2008</td>
<td>VÍCTOR M. WILSON</td>
<td>40</td>
<td>PUBLIC UNIVERSITY</td>
</tr>
<tr>
<td>JULY/2008</td>
<td>ÁNGELES VERDÚZCO</td>
<td>59</td>
<td>INDEPENDENT</td>
</tr>
<tr>
<td>NOV/2008</td>
<td>ROSA XICOHTÉNCATL</td>
<td>52</td>
<td>PUBLIC UNIVERSITY</td>
</tr>
<tr>
<td>NOV/2008</td>
<td>CARMEN REZA</td>
<td>38</td>
<td>PUBLIC UNIVERSITY</td>
</tr>
<tr>
<td>NOV/2008</td>
<td>NORA FERNÁNDEZ</td>
<td>53</td>
<td>PUBLIC UNIVERSITY</td>
</tr>
<tr>
<td>AUGUST/2009</td>
<td>MARCOS BUCIO</td>
<td>47</td>
<td>PUBLIC UNIVERSITY</td>
</tr>
</tbody>
</table>
A brief description of some dissertations recently defended (July, 2008) presented at CEJUS-CIDE follows:

Rocío González’s dissertation was on “Molecular identification of Coccidioides SPP in the Comarca Lagunera Region, in North-eastern Mexico: a new endemic area for Coccidiodomycosis”. The Coccidiodomycosis is a lung mycotic illness, endemic of the Southwest USA, Northern Mexico and several semi-arid regions in Central and South America. Dr. González’s research was able to identify an endemic area of the disease located in the “Comarca Lagunera” region, Northeast Mexico. The identification of the endemic area helps diagnose the illness correctly, often mistaken as pneumonia, thus giving patients the right treatment, and saving many lives. Figure 2 shows the areas where the endemic illness takes place.

Figure 2. Regions where the coccidiodomicosis takes place, both in Mexico and South USA.

Víctor M. Wilson’s dissertation in phyto-mining is titled “Hyper-accumulation of gold chemically induced in eight vegetable species”. In 1998, it was discovered that gold absorption may be induced in plants. This procedure known as “induced hyper-accumulation” has drawn the attention of both scientists and entrepreneurs. Mexico, with a long mining tradition did not have a team of scientists to do research in “phyto-mining”.

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Víctor contacted the only two existing specialists in the world, one in New Zealand, the other in Switzerland. With the advice of the experts, Víctor experimented with eight plant species. Three yielded a profitable gold “crop”. With his results, Víctor was able to defend his dissertation and get the doctoral degree. Now he is considered a world specialist in phyto-mining.

Marcos Bucio Pacheco made an important project with transcendental significance for the global warming issue. Dr. Bucio worked on tele-detection, via satellite imagery, of chlorophyll stress in an arid corridor in the state of Sinaloa. He composed a periodic series of satellite images that led to important implications for global warming. Dr. Bucio began work on this project after he detected a kangaroo rat population, i.e. a desert rodent, some 300 kilometres beyond the desert boundaries in the state of Sinaloa. Dr. Bucio’s work provided accurate statistical data on changing climatic conditions for a period of three decades beginning with the 1970s.

**Going from local to global.** CIDE’s model enables students to get in contact with top people in their field of interest, making use of the information and communication technologies. These contacts enable graduates to participate in international conferences, sometimes in collaboration with “global” scientists, thus gradually inserting into mainstream science. The model promotes knowledge production *from the bottom-up* by recognizing locally felt problems of regional communities and working on the solutions, thus making it more socially responsible. Table 2 shows examples of renowned international contacts made by some of the graduates during their dissertation research.
Table 2. Examples of “global” contacts made by Ph D students in the course of their dissertation research.

**CIDE’s other contributions**

CIDE’s proposal represents a fresh and innovative approach to scientific knowledge, going straight to the core: doing research that leads to the solution of real problems. It has the virtue of promoting learning and research that forms leaders in a specific field. As well, it is accessible to all those that are willing to carry out work in an ordered, systematic and scientific manner.

It is an innovative approach also in the sense that it reflects the needs of a less privileged segment of local societies in which the students are immersed. CIDE is thus a social-academic entrepreneurial approach that serves as an example of Mode 3 knowledge production, which we discuss elsewhere (Jiménez, 2009).

Thus, CIDE is an example of social entrepreneurship that dares to do things differently from the mainstream. It is not aimed at making a profit, but rather to the formation of people who take the responsibility upon themselves for developing Mexican society, from the bottom-up, local level. By combining various educational tools, as outlined above, the Center promotes better access to education for people in the provinces.
and already working professionals, as well as learning that involves research projects that will have a direct impact on local communities. This is a clear example of the concept of development in Ackoff’s sense (1974), that is to improve one’s and other’s quality of life with the means at our own disposal.

CIDE’s efforts are a valuable educational contribution in Mexico. This is reflected in its official recognition by the Ministry of Public Education and Culture of the State of Sinaloa. Through the various scientific communities it has created in different regions of the country, students in diverse graduate programs become capable scientific researchers. This has been verified through the experiences of its graduates (López-Pérez, 2004), which helps to legitimate CIDE in the opinion of mainstream educators, who have sometimes been skeptical about the alternative educational model for innovation and development.

To focus on the shift from teaching to learning based on problems is one of the strongest aspects of CIDE’s approach. The Center enables students to get in contact with the top people in their field, both locally and globally, who can help to enhance and guide their research. It promotes knowledge production from the bottom-up, i.e. learning and research that is socially responsible to local communities. CIDE stresses the importance of motivation among students, highlighting the contemporary turn to learner-centered educational systems. Though it has thus far had a limited impact nationally, it is nevertheless very important regionally and as such makes a significant contribution to modern Mexican society.

References


Prof. Stefan Kuhlmann
Endogenous vs. Exogenous Models for Innovation Policy in Late Industrialising Countries

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Twente University, The Netherlands
German Development Institute, Bonn, Germany, and Twente University

This paper develops the argument that since the 1990s governments of Late Industrialising Countries (LIC) have started defining their SI policy strategies under increasing exogenous influence. Growing international competition in the global economy and a ‘pluralization’ of international actors in science and politics build a framework of ‘globalization’ that shapes the domestic policymaking processes. As states rarely define their policies in isolation, policy transfer and learning have become common practice. International governmental and non-governmental organizations promote policy models and guidelines, particularly for the developing world. But how useful are these lessons that derive from the industrialized countries in a developing economy? How do governments in LIC perceive problems that require SI policy intervention? Under which conditions do they adopt policy advice from international organizations or experiences from other countries? When, in contrast, do policy innovations emerge? This paper presents a framework for the analysis of public SI policy-making in LIC. Evidence derives from qualitative research in Brazil and South Africa, two countries with GINI Index values over 50, and medium values in the scientific-technologically related World Development Indicators. We argue that LIC define their policy strategies using three sources of legitimacy: They are firstly domestic social and poverty oriented policies, secondly domestic techno-nationalist interventions in national firms, and internationalization via the UN or in collaboration with the OECD and other international and multilateral platforms. The global ideological and economic-financial environment strongly affects the policy choices in these countries and the frameworks for policy planning. These internationally promoted frameworks do not necessarily meet the domestic needs. This article presents preliminary results about their impacts on the domestic STI system and policy.

1. Introduction

Most of the understanding of science and innovation (SI) policies derives from the experiences in the industrialized world. Over decades, governments in Western European countries, the US and Japan pursued explicit strategies to enhance their performance in science and research based innovation (Smits et al. 2010). Based on their national experiences, the industrialized nations delegated responsibility to International Organizations (IO) - such as the OECD and special entities within the UN- to refine the formation of science and innovation related policies and to increase impact on economic growth and development. Today, several global governing institutions provide models and programs elaborated and based on own research or in collaboration with social scientists. The ‘recipes’ for policy making (Drori and Ramirez 2003) address mostly the developed world. Recently, nevertheless, relevant international institutions and clubs such as the OECD and the G8 have started to expand their outreach beyond the
participating states and involve late industrializing countries in their programs, reviews, dialogue forums and other forms of ‘soft’ governance.

Challenging national approaches to SI policy, we argue that the global context matters for domestic SI policy making. Over the last decades, governments in Late Industrializing Countries (LIC) have started formulating explicit science and innovation policies within their overall development strategies. After decades of rule under authoritarian regimes, new democratic governments started to think about new development strategies that would bring economic welfare for all their citizens. In Asia, Latin America and Africa governments chose development strategies that prioritized the issue of science and technological innovation in different ways. Whereas governments in Asian Newly Industrializing Countries and China heavily invested in research for building own technological capability (Edquist and Hommen 2008; Etzkowitz and Brisol 1999; Hu and Mathews 2005; Lall and Urata 2003; Mahmood and Singh 2003), Latin American and African countries increased their dependence on foreign knowledge (Arocena and Sutz 2001; Bernardes and da Motta e Albuquerque 2003). Most investment in Science and Innovation was not generated in the national economy, but derived from external funds and very few local public and private investment (Amsden 2003).

The GINI Index shows that inequality is higher in the African and Latin American countries than in Asia. All countries showing a value in the GINI Index > 50 are in Latin America and Africa. Among these countries, South Africa and Brazil are young democracies with the most technologically advanced economies on both continents – Latin America and Africa – that simultaneously face the highest rates of inequality and. We use these differences as the starting point for the research problem that we address in this paper: the public interventions in developing countries with high levels of inequality and simultaneously technological advance under influences of globalization. We ask the following research questions: How do governments in developing countries perceive SI policy problems? How do governments set priorities on public policy intervention in SI under the conditions of high inequality and poverty? Do governments adopt conventional SI policy approaches or do new forms of policy intervention and policy innovation emerge?

Our analysis consists in three parts: first, we show the rationale and evolution of SI policy in late industrializing countries with a focus on the role of the influences of external powers and international cooperation. In the second part, we develop a framework for the analysis of the external influential factors on the domestic science and innovation policies along domestic and international interests, institutions and ideas. The third and final part presents preliminary findings and conclusions. Evidence is derived from the World Development Indicators and a qualitative analysis of interviews and documents related to the questions such as research papers, newspaper articles and

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58 Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. A Lorenz curve plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area under the line. Thus a Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality (World Bank 2009, WDI).
government documents from two highly unequal democracies with substantive technological-scientific development, namely South Africa and Brazil.

2. Science and Innovation Policy in late industrializing countries

Many attempts in the literature try to conceptualize distinct developing countries according to their technological and economic performance. Some authors refer to ‘late industrializing countries’ (LIC) as countries which developed technological capabilities to generate mid-technology industries first and moved into high technology sectors later\(^59\) (Amsden 2003; Viotti 2001). But the industrialization paths of these countries diverge as well as their policy efforts, the significance of international cooperation and their dependence on other countries. Mani intended to identify a group of eleven technology generating countries as those who have US registered patents (Mani 2004). Da Motta e Albuquerque takes regional inequality into account and conceptualizes South Africa, India, Brazil and Mexico as ‘immature innovation systems’ (da Motta e Albuquerque 2003). This logic comes closer to the ‘in between status’ of LIC resulting from high inequality in income and regional concentration of technological capability clusters between developing countries without a scientific basis and industrialized countries with full-fledged innovation systems. So far, there is no clear-cut definition helping to isolate a defined group of LIC.

Table 1: Concepts on developing countries and scientific-technological advance

<table>
<thead>
<tr>
<th>Title and Author</th>
<th>Defining criteria / Indicators</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explicitly related</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immature Systems of Innovation (da Motta e Albuquerque 2003)</td>
<td>Developing economies with highest patent data from the USPTO, scientific publications data from ISI data base</td>
<td>South Africa, India, Brazil and Mexico</td>
</tr>
<tr>
<td>The Rise of the ‘Rest’ (Amsden 2003)</td>
<td>Robust manufacturing expertise (e.g. in the production of silk, cotton textiles, foodstuffs and light consumer goods) allows to move into middle and later high technology sectors</td>
<td>China, India, Indonesia, South Korea, Malaysia, Taiwan, Thailand, Argentina, Brazil, Chile, Mexico and Turkey</td>
</tr>
<tr>
<td>Government, innovation and technology policy (Mani 2004)</td>
<td>The number of US registered patents divides developing countries into Type 1 countries with the potential to generate own technology whereas type 2 countries are mere assemblers of imported technology</td>
<td>Type 1: Taiwan, Korea, Singapore, India, South Africa, Brazil, China, Mexico, Argentina, Malaysia, Type 2: Paraguay, Uruguay, Venezuela,</td>
</tr>
</tbody>
</table>

\(^59\) Amsden refers to China, India, Indonesia, South Korea, Malaysia, Taiwan, Thailand, Argentina, Brazil, Chile, Mexico and Turkey as late industrializing countries (Amsden 2003).
We define LIC as those countries that determine themselves as developing countries according to the criteria established in the WTO with an average GINI inequality value of more than 50, and simultaneously show medium values of technological advance (measured in high technology exports, patents, researchers and technicians in R&D, scientific publications and R&D expenditure).

These countries benefit from technological capabilities in some sectors because they trigger economic growth, but at the same time, inequality and poverty constrain economic development. A large proportion of the population remains excluded from the labour markets and the benefits and wealth deriving from industrialization. Economic growth on the other hand, translates into economic power and allows governments to become stronger voices in the international system. These tendencies result in an international SI policy that manifests itself in LIC taking the lead in the groups of

<table>
<thead>
<tr>
<th>Implicitly related</th>
<th>National Innovation System in Less Successful Developing Countries: (Intarakumnerd et al. 2002)</th>
<th>Degree of learning intensity in the economy, degree of technological intensity in manufactured exports</th>
<th>Algeria, Egypt, Morocco, Lebanon, Tunisia, Syria, Pakistan, Brunei, Philippines, Thailand, Vietnam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implicitly related</td>
<td>BRICS e.g. (Cassiolato and Vitorino 2009)</td>
<td>Regional focus, technological advance</td>
<td>Brazil, Russia, India, China, South Africa</td>
</tr>
<tr>
<td>Implicitly related</td>
<td>Emerging Economies (OECD 2008)</td>
<td>Trade, economic growths</td>
<td>BRIICS: Brazil, Russia, India, Indonesia, China, South Africa</td>
</tr>
<tr>
<td>Implicitly related</td>
<td>Transition Economies (IMF Working Papers e.g. (Feltenstein 1990)</td>
<td>Countries in transition from a communist political and economic system to democracy</td>
<td>Eastern European Economies, Russia</td>
</tr>
<tr>
<td>Implicitly related</td>
<td>BRIC (Wilson and Purushothaman 2003)</td>
<td>Economic growth of BRIC Economies</td>
<td>Brazil, Russia, India, China</td>
</tr>
<tr>
<td>Implicitly related</td>
<td>BASIC (Joined Statements of the BASIC group 2009, 2010)</td>
<td>Self determined group resulted from UN Conference on climate change COP 15 based on similar interests in the climate change negotiations</td>
<td>Brazil, South Africa, India, China</td>
</tr>
</tbody>
</table>
developing countries and simultaneously engaging with international organizations dominated by the industrialized world.

3. Science and Innovation Policy in the context of ‘globalization’

Literature on governance of SI policy in a global context is relatively scarce. Most research in innovation studies concentrates on the national business dynamics and firms behaviour, as private corporations are the main users and producers of new technology. The studies dealing with policy and governance concentrate on policy impacts on the determinants of innovation in firms rather than on the origins, development and decision-making processes for policies in public administrations and related actor arenas (Carlsson et al. 2010; Chaminade and Edquist 2010; Cozzens 2010; Smith 2010; Smits et al. 2010).

The predominant concept in innovation research over the last two decades was the National Systems of Innovation approach (NIS) that suggests that the boundaries of innovative activities constitute in the administrative unit of the nation-state. Although acknowledging that there are international actors that innovation systems respond to the authors suggest that the national context matters as the main unit for the innovative performance.

The National Systems of Innovation (NSI) approach suggests that there are different layers of actors consisting of a political system, an economic system and a science system. Nevertheless, simultaneously international influences, interaction and cooperation occur in all three layers. Globalization research has focused in the 1990s on the internationalization of the economy and the policy responses, as we will see below. Other authors looked at the international cooperation patterns in the sciences (Wagner 2008). This paper and other authors contribute to the understanding of the cooperation between international agencies and domestic governments. The graph below illustrates the international dimensions of an ‘innovation system’ beyond the national domain in the centre.
This heuristic presents relationships and arrangements between national and international actors beyond the national framework. These relationships and arrangements can be categorized as hard law arrangements and soft law arrangements. Hard law and soft law mechanisms were first distinguished by (Abbott and Snidal 2000) to differentiate between legally binding agreements shown on the right and soft mechanisms as reviews, rankings, dialogue and policy tools and the left side of the graph. This analysis focuses on the interactions between governments and international organizations, shown on the left side of the graph linking up with two currents strands of research in international relations, (foreign) policy analysis and innovation studies: The first strand focuses on the influence of economic and technological ‘globalization’ on domestic politics. Increasing transnational economic interactions, in trade and investment, proof to impact on domestic policy choices. In recent years, two issues dominated this debate: a) the capability and autonomy of national states to interfere in the globalizing economy and b) the convergence and divergence of national policies resulting from external influences. It became clear that ‘globalization’ is not occurring to a country at a sudden and from the outside; rather governments either control or promote transnational activity (Sassen 2002). In the past, scholars argued that the manoeuvring room of national policy-makers was narrowed by new international forms of production and trade, corporate behaviour, and institutional supervision (Mayntz 2003; Parsons 1996; Strange 1996). Empirical studies never came up with clear results towards either convergence or divergence (Schirm 2007), even though several policy domains such as economic policies, trade policies (Keohane and Milner 1996; Scharpf 1997), tax policies and environmental policies have been intensely researched. Although these
questions are equally relevant in SI policy, little research has been devoted to this field so far. An early analysis of SI in the context of foreign policy in the 1960s makes a strong argument for the relevance of its linkages in the process of policy definition in the US logic of the Cold War (Skolnikoff 1967). Later work in international relations contextualized the changes in foreign policy that resulted from Information and Communication technologies (Weiss 2005).

The second strand of literature derives from innovation research. Jacobs argued that governments combine SI strategies against the background of ‘globalization’ as a mixture of four ideal types of innovation policy choices (Jacobs 1998). He identifies four different ‘development logics’: i) adaption to international developments, ii) international cooperation aiming at policy coordination and harmonization, iii) policy competition directed at the same objectives that other countries have and iv) differentiation or policy competition that aims at strengthening the actual specialization patterns. Although the point is not explicit in Jacobs’ analysis, he roughly distinguishes between exogenous and endogenous factors that influence the policy choices. His study draws on the experience of industrialized countries, particularly small countries in the EU, but it lacks an in-depth analysis of the concrete policy processes and does not identify the external actors. Fransman (1997) asked whether national technology has become obsolete under the influence of globalization; his analysis of Industrial and Innovation policies of the Japanese Ministry of International Trade and Industry (MITI) revealed that state bureaucracies reacted rather pro-actively than passively to support domestic firms into the global economy and to integrate international players in the Japanese innovation system (Fransman 1997). Institutionalist scholars argued that national strategies for organizing national policies in different fields, also in education and science systems, are not newly created in each country but rather adopted from ‘cognitive models’ that propose how certain policies should be organized (Schofer and Mceneaney 2003, 45). One example for policy diffusion and institutions is the emergence of Ministries of Science and Technology worldwide during the 1960s (Jang 2003).

In terms of ‘political globalization’ IOs can be determining players in mainstreaming policy frameworks, institutions and ideas (Béland 2009; Chwieroth 2007; Finnemore 1993). Finnemore (1993) concluded in her analysis of UNESCO’s promotion of science policy since the 1960s that interest in international-level sources of state policy in 24 countries has been increasing. She shows that IOs have an active role in the international system rather than being reactive to national interests, as neorealist theory assumes. The literature on epistemic communities, ideas, and transnational relations deals with international sources of state policy in which international actors contribute to state policy debates in a constructive rather than merely in a constraining way. They ignore the role that IOs play in domestic policy-making (Finnemore 1993, 593).

As states rarely define their policies in isolation, governments keep looking for useful policy models from other countries. They find useful experiences often in other countries, international platforms and recommendations provided by international organizations. Recent literature conceptualizes these international providers of policy solutions as a ‘world polity’ (Drori and Ramirez 2003) that provides ‘recipes’ or ‘lessons’ through policy learning and policy transfer (Dolowitz and Marsh 2000; Rose 2005). Both are common and useful, but transferring policies also bears risk, because success is not
guaranteed, as the adopted strategies may not have the expected effects if introduced into different countries. These mechanisms of interaction between the IO and its member countries distinguish between legal, cognitive and normative governance in case of the OECD (Marcussen 2004). The author showed that the organization increasingly uses soft mechanisms that work through rankings (normative governance) and surveillance (cognitive governance). He does not consider that these mechanisms are also effective beyond the circle of member states as LIC who refer to the conceptual work of the OECD and submit themselves to policy reviews and rankings. In sum, the relationship between IOs and domestic politics is a relevant field that still requires further exploration (Stein 2008) particularly in the field of innovation research that focused on national system approaches for the last two decades.

4. A Framework for Analysis - Science and Innovation Policy in LIC in the context of globalization

To overcome the gap in the literature on STI policy in LIC, we conceptualize it as a process determined by three sources of legitimacy in multi-dimensional competing policy fields. These sources determine the outcomes in STI policy at the both international and national levels. Therefore, it is a result of the domestic pressures and international requirements.

We argue that these policies in LIC need to address all three poles in order to achieve legitimate and effective results. To structure the analysis, we combine the three poles with three criteria from the school of comparative political economy. The analysis of comparative political economy distinguishes three approaches guided by interests, institutions and ideas (Hall 1999; Kopstein and Lichbach 2005). To determine the conditions that produce a policy outcome, regime type or development path, interests, institutions and ideas are frequently used tools to structure comparative analysis. These tools help to analyze institutional structures, understand the actor’s interests and to disentangle the ideas that guide their behaviour. In this analysis, we apply the three i to understand the main rationales and trajectories for STI policy making.

Ideas: Ideas, defined as beliefs held by individuals (Goldstein and Keohane 1993), guide human behaviour. Rational choice theories marginalized the importance of ideas for policy choices over the last decades. Ideas define not only the understanding of policy problems; they also shape the interests of actors and the solutions to policy problems. Ideas unify and distinguish actors and shape the institutions they create. Ideas determine knowledge networks, epistemic communities 60 (Haas 1992) and identities (e.g. religions, nations).

Interests: We assume that all actors involved in the policy arena behave conforming to their interests that emerge from their material interests as well as their identities and beliefs. As opposed to schools of rational choice assuming that all individuals act to minimize their material losses and maximize their gains, we assume that interests are not purely focused on material wealth but also fuelled by passion,

60 Haas defines epistemic communities as those groups that share causal and principled beliefs as well as a common knowledge base and joint interests. These criteria distinguish them from interest groups and social movements, disciplines and legislators.
prestige, honour and power although these determinants of the concepts of interests have vanished or at least weakened over time (Hirschman 1997).

**Institutions:** Institutions are the rules of the game in politics. The institutions in a country shape their political systems, their political arena and they influence the kinds of policies being formulated and implemented (Kopstein and Lichbach 2005). Institutions evolve over time and are difficult to change (von Beyme 2006). Putting it in March and Olsen’s words: ‘An institution is a relatively enduring collection of rules and organized practices, embedded in structures of meaning and resources that are relatively invariant in the face of turnover of individuals and relatively resilient to the idiosyncratic preferences and expectations of individuals and changing external circumstances’ (March and Olsen 1989). Inevitably, institutions advantage some actors and disadvantage others. Therefore, the study of legitimacy in institutions, the interest groups who push for their creation according to their ideas, is inevitable to understand the policy outcome.

Given its nature, actors in STI policy, particularly in the Sciences and to a lesser extent in the technology policy community in LIC concentrate in small elites. Scientific research is complicated. It requires highly skilled individuals of which few of them manage to produce internationally recognized results. The market of ideas around the world is highly competitive.

Therefore, the first basic demand in the science policy in LIC is that few international known scientists request more money for their research. The second basic demand is that governments liberate resources to invest into state-controlled and prestige enhancing technologies attending to their own demand.

The third –and least articulated-- demand is to enhance the socio-economic benefit through research investment.

These demands can be summed up as three poles for legitimacy that shape STI policy: technonationalism, social inclusion and internationalization.
Graph 2: Modern Science and Innovation Policy between three poles of legitimacy

Technonationalism vs. Social Development

The framework has two domestic dimensions that we call ‘techno-nationalism’ and ‘social development’. Historically, governments have shown tendencies towards techno-nationalist approaches. Techno-nationalism is a direct form of public policy intervention that favors single domestic firms. These firms are primary beneficiaries of public funds. Although there might be programs and incentives that address the whole industry, public enterprises and single private firms with technological missions of state interests are frequently favored as recipients for government support. Frequently, governments who have the objective to develop a new technology, set up firms with public funding that then receive the mandate to develop that particular technologies and commercialize them.

Tendencies of techno-nationalism have increased in both industrialized and industrializing countries and as a consequence, governments have come under growing pressure to legitimize their redistribution practices in terms of their impacts on public welfare (Ostry and Nelson 1995). Priority setting through technologies favoring particular sectors is a way of ‘picking winners’, because some sectors and therefore firms are a part of an exclusive circle of beneficiaries. These beneficiaries are frequently public companies. Governments in countries that have been historically inward looking have always regarded the need to import technologies as a sign of national weakness. Import substitution strategies start from strong techno-nationalist traditions towards
technological development and sought to develop and maintain domestic technological capability and support parastatal enterprises.

Evidence of technonationalism merging with modernization occurs frequently under the rule of autocratic regimes that try to demonstrate modernity through visible and prestigious technology projects in high technology and defence. Democratic regimes’ governments implement major technology projects as well, with the difference that these efforts have -- at least normatively -- the objective of benefitting the public good.

Techno-nationalist behavior in democracies is likely to cause controversy among voters because of the limited circle of beneficiaries. Funding for infrastructure and service delivery compete with expensive technological development projects that do not have immediate development impacts. Governments, in consequence, achieve legitimacy for their STI policy efforts if they are integrated into the overall development strategy, and secure access to the benefits of technological innovation for the public good. Technological missions for prestige and self-sufficiency were common practice in the 1950 to the 80s, particularly in developing countries under autocratic regimes.

<table>
<thead>
<tr>
<th>Indicators for techno-nationalist state behavior are therefore:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- large R&amp;D budget allocation to single firms</td>
</tr>
<tr>
<td>- large R&amp;D budget allocation to public enterprises and state controlled technology (e.g. nuclear)</td>
</tr>
<tr>
<td>- % of R&amp;D expenditure in public research institutions vs. systemic programs that are available for whole value chain</td>
</tr>
<tr>
<td>- Competitive vs. equal funding</td>
</tr>
</tbody>
</table>

**Social development and poverty reduction: Benefits do not trickle down**

The opposite pole of techno-nationalist orientation of SI Policy is an orientation for social development and inclusion. This direction suggests policies that ensure the maximum social outreach of SI in order to reduce inequality and combat poverty. Social impacts of technological innovation are desirable, but they are not naturally achieved through trickle down effects as linear models suggest. That is partly because research is not focused on societal needs. The conclusions of authors like Keith Pavitt (1998) suggesting that research responds to societal needs because national societies influence their science basis and their respective research activities. This assumption does not necessarily apply to developing countries: Here, the researching elites may consist of actors with completely different interests than those who are disadvantaged in the same society. In societies divided by race, religion, income inequality and levels of education these characteristics are reflected in the science base, too. Scientific communities may consist of small homogenous elites that then determine the research priorities according to their own interests. Therefore, governmental intervention is necessary in unequal societies to incentive research in areas that matter to the lives of poorer groups of the population. But this intervention is either avoided or highly disputed because of the value of academic freedom.
Assuring access and technological diffusion

The second issue to enhance social development for governments is to ensure technological diffusion and access to technological innovation. Often this is a matter of infrastructure and international intellectual property regimes. Infrastructure for technological inclusion is an issue that is usually demanded by the society and or not sufficiently delivered by the public administration. It covers a wide range of issues, from innovation in e.g. housing projects, digital inclusion as well as access to energy, water and medication.

Conflicts with the techno-nationalist and the social development agendas can derive from regulation of intellectual property rights (IPR) (Forero-Pineda 2006; Lall 2003). IPR is part of the public domain as the state being the monopole for making and enforcing law. International regulation restricts access to innovation and protects the advantages and benefits for the innovator for a certain amount of time. IPR frameworks in the developing world frequently derive from international agreements. International IPR regulation is one of the issues that national governments face in internationalization.

<table>
<thead>
<tr>
<th>Indicators for state behavior committed to social development and poverty reduction are therefore:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- programs to support smallest, small and medium sized enterprises</td>
</tr>
<tr>
<td>- support to spin offs and start up of new enterprises</td>
</tr>
<tr>
<td>- support of local innovation system in low income communities</td>
</tr>
<tr>
<td>- Research incentives and funding on development and poverty issues</td>
</tr>
<tr>
<td>- Education, training and human resource development</td>
</tr>
</tbody>
</table>

Internationalization

The international dimension refers to the international and national activities that governments undertake in pursuing international commitments and interests in STI. These activities include STI diplomacy, a term that refers to negotiating bilateral and multilateral STI cooperation at the international level, administrating and implementing the result of these negotiations at the national level (UNCTAD, Putnam 1988). International influences find their way into domestic politics not only through negotiation and hard law. Cognitive influences, ideologies, theories and ideas also influence the understanding of policy problems and policy design (Abbott and Snidal 2000).

International organizationsshape the global policy agendas and influence the direction of national policies in an uncoerced way, also conceptualized earlier as their role as ‘teachers of norms’ (Finnemore 1993). Soft governance mechanisms can usually draw on practices of exchanging experiences, benchmarking and policy learning.

A further international dimension is international competition for ideas and excellence of science, technology and innovation. Governments try to enhance scientific
excellence through strategic bilateral cooperation, scholarship programs and migration incentives for highly skilled researchers.

<table>
<thead>
<tr>
<th>Indicators for internationally oriented behavior in SI Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>- adoption of international concepts for policy framing</td>
</tr>
<tr>
<td>- policy transfer</td>
</tr>
<tr>
<td>- reactive policies to global (security/ economic/ financial) threats</td>
</tr>
<tr>
<td>- strategic international cooperation</td>
</tr>
</tbody>
</table>

5. Methodology

We chose Brazil and South Africa as case studies for this analysis. Both countries are leading in terms of scientific-technological advance and simultaneous inequality and poverty according to the definition above. In a comparative process analysis, we investigate the international and domestic driving forces of the Science and Innovation policy that started in the 1990s. According to our theoretical framework, we analyze institutions, ideas and interests in SI policy making between techno-nationalism, social development and internationalization. The analysis draws on secondary data of state budget allocation to SI, and own 82 semi-structured interviews with high-level policy makers, firms, representatives of firm associations and academics specialized in the field.

6. Preliminary findings

Ideas: Ideologically, there are two main principled beliefs guiding modern and traditional science, technology and innovation policy. The first is that government expenditure on research and development (GERD) leads to higher private sector spending. Second, higher R&D spending means higher innovation, and third, higher innovation rates lead to higher competitiveness of the economy, higher growth rates and consequently, increases in societal welfare. This is the logic why governments invest in R&D, and research. The next question is how governments can intervene in the most efficient way, so that all these causalities come true. This question manifests in another conflict about the practice of STI policy between the linear understanding versus a systemic understanding of scientific-technological development and innovation. This conflict derives from theories around the role of government in science, technology and innovation and manifests itself globally as well as in the two countries that are subject to this analysis. During the post-war period, a linear model dominated the thinking around science and technology and less on innovation and the role of policy. The principal assumption of this approach is that government support to basic sciences naturally triggers into applied sciences and innovation. Vannevar Bush’s essay on ‘Science- the endless frontier’ suggested these ideas after the Second World War and the creation of the atomic bomb. In consequence, during the 1950s, throughout the world, governments started to set up research council to support basic sciences (Jang 2003). The ideas around the role in government in advance scientific-technologically also tackled the question about international development and models for developing countries. As Finnemore
(1993) shows, some countries established science bureaucracies although there were only few scientists to coordinate (Finnemore 1993).

The influence of international organizations manifests itself in their conceptual notes, policy briefs, rankings and measurement tools that set international standards. UNESCO, for example, established a system of indicators to measure scientific-technological performance. The OECD worked on a similar task simultaneously. Finally, the OECD system merged with UNESCO’s efforts and together they promoted norms that derived from the experiences of rich industrialized countries in the developing economies. As a result, governments there established agencies to a support conforming measurable R&D activities. This narrow focus on R&D manifests itself in many developing countries.

In South Africa and Brazil, governments intervened following the linear logic during the 1980s and 1990s. The apartheid regime in South Africa had no explicit strategy for scientific-technological interventions. The interventions fed into the overall idea to preserve white supremacy. Therefore, scientific-technological activities aimed to secure health, energy and food security to the white minority. The research councils’ staff consisted of individuals that belonged to the white minority and worked relatively independent from the government. The government’s funding in STI went to the research council’s basic sciences, and the state enterprises ESKOM, SASOL and research institutions like Pelindaba for research in nuclear and coal liquefaction technologies. As non-whites could not own business by law, the business sector was very small. This factor, the high independence of the scientists and the increasing international organizations pushed the South African pre-democracy science into the ivory towers of the research councils. There was no demand or incentive for applied research except around the technological missions.

With the return to democracy, South African government and society designed democratic and inclusive policies to the most up-to-date standards. Given the centuries of repression of the majority of the population in the country, social inclusion was the main preoccupation in the modern policies throughout the different policy fields. In SI policy, South Africa was among the first countries to adopt the national system of innovation in their policy frameworks and measurement in 1996. The White paper suggested the introduction of a research foundation and an innovation fund and other institutional novelties to strengthen the national system. Nevertheless, the funding structures follow a linear model that focuses on R&D output mostly in public research institutions (NACI 2007).

In the Brazilian case, scientific-technological policy intervention in the 1980s and 1990s resulted from the neoliberal thinking of the time. The financial and economic crisis in the 1980s led to massive budget cuts. In consequence, government took advantage of the possibility to finance S&T policy through loans from the World Bank. The PADCT programs from 1983-1998 in Brazil are still controversial regarding their impact. On the one hand, the loans secured funding for research institutions and continuity for the research programs. On the other hand, the conditionalities asked for reducing the ICT programs, introduced competitive funding forms that, according to the critics, benefitted only the established elites. Industrial policy and therefore innovation policy, were ‘taboos’ during both the decades of the 1980s and 1990s in Brazil. Another impact that
derives from the ideological paradigm promoted by the Washington consensus is the decrease in economic development research. By the end of the second administration of President Fernando Henrique Cardoso, when the next global financial crisis in 1998/1999 threatened to eliminate large parts of the public budget, the government reacted. Copying the institutional example of the petrol fund, that secured funding for research for Petrobras in oil processing and drilling, the government created 15 other funds for research in prioritized areas. The logic of the funds, repeated the logic of the PADCT in financing mostly public research in strategic areas.

Only in 2001, in the first national conference the political discourse shifted towards innovation, in Brazil. A white paper wrapped up the academic discourse and good intention, but implementing concrete interventions and policy strategies was a task left for the next administration came into office in 2003. The Lula administration took a year to get on its feet in STI. The interventions have so far been a mixture of continuing the business of usual and stronger focus on industrial and innovation policy and social inclusion. The ideological conflict between the linear and the systemic nature of innovation manifests itself in the institutional development as well as the policies introduced in both countries.

**Institutions**

Institutional development evolved in three roughly distinguished phases: i) colonial institutions, ii) post-WWII institutions iii) modern institutions. External influences in science politics appear from their beginnings in South Africa and Brazil through colonization. Historically, first formal scientific institutions evolved in both countries early under colonial law. The colonial powers established research institutions according to their demands, which were concentrated in health, agricultural and veterinary sciences and mining.

In both countries, these early attempts of institutionalization in the sciences derive from the predominant models of scientific organization in the home countries of the dominant colonizers.

In South Africa, the British model prevailed. Although there were indigenous scientific activities in the pre-colonial communities, the British were the first ones to establish formal science councils according to their known standards from their home country. Initially the British interest in the Cape was its strategically important harbour, but competing with the Dutch, the authorities hurried to build settlements and institutions. Thus the early institutions like the Royal Observatory (1820), the South African Museum (1823) and the South African College (1829) as well as the medical research institutes were all in the Cape. In Brazil, Portuguese, Dutch and French tried to colonize the country at different stages. Despite the competition, Portuguese were less determined about establishing scientific institutions in their colonies than the English and even forbid it (Cassiolato and Koeller 2009). So the first formal research institutions in the country were only created when the Portuguese kings moved to Brazil in 1808. These derived from French models were equal to scientific institutions in Portugal. In both countries, these institutions represented the interests of the colonial powers to serve the demand in the colonies particularly in health, veterinary sciences, geology and mining as well as biological and botanical sciences.
In the post-war period, formal institutionalization to support sciences was highly influenced by the external global environment. In Brazil, formal institutionalization started only in the 1951 when the Getùlio Vargas administration established the National Science Council (CNPq). This institutional novelty resulted from the aspirations of nuclear technology. Under US American influences, the government agreed to create a national agency to regulate the use of nuclear technology according to the standards of the newly created International Atomic Energy agency (IAEA). The Brazilian government was already discussing possible creation of a ministry for science and technology at that time, but in the end American interests succeeded and the ministry did not exist until 1985. Science and technology under the military dictatorship was a strategic priority for defence, energy, agriculture and space. In the period from the 1950s to the late 1970s, some important research institutions developed that grew to be important actors in the present. The Brazilian Enterprise for Agricultural research EMBRAPA, today holds over forty specialized research institutions on agriculture. The Institute of Space research (INPE) and the Brazilian Aeronautic Enterprise (EMBRAER) evolved to be the leading aircraft manufacturer for military and civilian use. PETROBRAS and the World Bank program laid foundations in the 1970s for research on biofuels today. Currently, the biggest innovation project is in the deep sea drilling to exploit the recently discovered oil fields in the Atlantic ocean.

The apartheid government in South Africa, in turn, never formalized a science policy and the institutions for scientific support. The only formal institution in the government responsible for sciences was a small unit in the Department of Education. Nevertheless, sciences were similarly directed to contribute to developing technologies in the strategic ‘missions’ energy, defence, nutrition and health. Financial resources went straight into the research councils and the technological missions that the apartheid defined as their priorities to achieve self-sufficiency under the conditions of international isolation. Research and development exercises to develop nuclear weapons happened covertly, also in cooperation with the Israeli government, one of the few countries that maintained close relationships with the apartheid government.

The Brazilian government created a formal ministry responsible for Science and Technology (MCT) under the first civilian government in 1985, before the first democratic elections in 1989. At the time, the National Science Council had already functioned for 24 years as an agency subordinated to the Department of Planning. Although staff were exchanged between the two organizations, there was a power competition between the two competing institutions about the roles of principal and agent. Over the years, the MCT strengthened its role as a principal in subordinating the agency, but quarrels continued to exist. A similar competition exists between the DST and the NRF in South Africa, as well, but to a much lesser extent.

The other important institutions created for finance of research was the Federal Foundation for the Studies and Research (FINEP), and a national development bank (BNDES) for general investment in infrastructure and development in the 1960s. The Development Bank for Southern Africa was only established in 1983.

The World Bank offered a contentious loan to the military government in 1983. The so called Program on Science and Technology (PADCT) was controversial in its conditionality. Given the neoliberal orientation of the time and the competition in
creating information technologies, the loan conditions aimed to weaken the Brazilian ICT industrial program. Furthermore, through the introduction of competing tenders for funding, the scientific community at the traditional, well-off universities benefited from the funds. This program continued over three versions until 1999 and supported the logic of the ‘science push’ in a centralized institutional setting rather than creating linkages and supporting weaker actors to join the system.

Modern formal institutions to support scientific-technological development to promote innovation emerged only after the return to democracy. In South Africa, the green paper and the subsequent white paper on Science and Technology foresaw the creation of the National Research Foundation (NRF) and the Innovation Fund in 1998. In 1994, the Mandela administration established a new Department responsible for Science and Technology support together with Arts and Culture (DACST). The department was not only overstretched in terms of a large variety of tasks, it was also understaffed in terms of quantity in qualified people. In 2002, the department split up into the Department of Science and Technology (DST) and the Department of Arts and Culture (DAC).

In Brazil, in turn, the first democratic governments under Collor and Itamar Franco had no explicit plans for Science, Technology and Innovation. During the first Cardoso administration, the Brazilian economy was suffering from high inflation. The macroeconomic framework to stabilize the economy derived from the ideas of the Washington Consensus that did not support any industrial and innovation policy. The logic of the WC assumed that the market regulated itself. After establishing the Plano Real, a monetary policy that introduced gradually a new currency aligned to the dollar and the capital inflow which devalued the ‘real’, the country suffered from the global economic and monetary crisis again in 1999s. In this context of macroeconomic instability industrialization and market-oriented science and innovation policy were taboos, in the logic of neoliberal thinking. For this reason, the World Bank and the IMF had powerful positions to influence the national policy designs. When inflation, again, seemed to threat the budget during Cardoso’s second term, the Secretary for Science and Technology managed to secure funds for research for several sectors in the economy. Because of the global threats to the macroeconomic stability in Brazil, the ministry created the ‘sectorial funds for science and technology’. The first fund was the ‘petrol fund’ that set an institutional example for the other 16 new funds. The funds have the objective to support innovation and development in strategically important sectors.

**Table 2. Sectorial Funds in Brazil**

<table>
<thead>
<tr>
<th>Sectorial Fund</th>
<th>Year</th>
<th>Funds transferred from FNDCT to Finep through the Sectorial Funds in 2009 in US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT PETRO - Oil &amp; Gas</td>
<td>1999</td>
<td>USD 34,395,000</td>
</tr>
<tr>
<td>CT ENERG - Energy</td>
<td>2001</td>
<td>USD 25,833,000</td>
</tr>
<tr>
<td>CT SAUDE - Health</td>
<td>2002</td>
<td>USD 41,763,000</td>
</tr>
<tr>
<td>Green-Yellow Fund (Not sector specific)</td>
<td>2002</td>
<td>USD 97,539,000</td>
</tr>
<tr>
<td>Subsidies</td>
<td></td>
<td>USD 59,995,000</td>
</tr>
<tr>
<td>Sector</td>
<td>Year</td>
<td>Budget</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>--------</td>
<td>--------------</td>
</tr>
<tr>
<td>CT ESPACIAL - Spatial</td>
<td>001</td>
<td>USD 82,971.000</td>
</tr>
<tr>
<td>CT AMAZONIA - Amazon</td>
<td>2001</td>
<td></td>
</tr>
<tr>
<td>CT BIOTEC - Biotechnology</td>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>CT AERO - Aeronautics</td>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>CT AGRO - Agribusiness</td>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>CT TRANSPORTE - Transport</td>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>CT MINERAL - Mineral resources</td>
<td>2001</td>
<td></td>
</tr>
<tr>
<td>CT AQUAVIARIO - Aquatic transport and shipbuilding</td>
<td>2004*</td>
<td></td>
</tr>
<tr>
<td>AUDIOVISUAL</td>
<td>2006*</td>
<td></td>
</tr>
<tr>
<td>FUNTEL - Communication</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>CT INFRA - Infra-Structure</td>
<td>2001</td>
<td></td>
</tr>
<tr>
<td>CT INFO - Informatics</td>
<td>2001</td>
<td></td>
</tr>
<tr>
<td>CT HIDRO - Water resources</td>
<td>2001</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>USD 307,000,000</strong></td>
</tr>
</tbody>
</table>


* These Funds were established under the Lula administration.

The sectorial funds’ focus is incentivising research. Every fund has a ‘management board’ that consists of government representatives, public research institutions or universities and firms. The institutional model prevailed and extended under Lula’s government (2003-2010). In 2004, the government tried to soften the sectoral design and passed the rule that every fund needs to spend 50% of its resources on ‘transversal actions’, cross-cutting interventions. These interventions were intents to strengthen ‘the national system of innovation’. They were combined with a whole set of new institutional arrangements to strengthen the linkages between the different actors in the system, as the concept requested. In the late 1990s and early 2000s, new agencies were established to help to implement the new focus on innovation, beyond Science and Technology. The Council of Management and Strategic Studies (CGEE) and the Brazilian Agency for Industrial Development (ABDI) both have the objective to contribute to establish linkages between scientific-technological and industrial policy. Although, again, innovation is not explicit in the organizations’ objective, ABDI states their mission as ‘promoting the implementation of the industrial development policy in coherence with the policies in foreign trade, science and technology’ (Lei 11.080). The CGEE acts as a think tank intending to ‘promote the interaction between the scientific-technological and the productive sectors’ and ‘provide technical and logistical support to public and private institutions’. With its status of a ‘social organization’ the CGEE is relatively independent. It holds fixed members in its council representing the ministries of science and technology (MCT), industry and commerce (MDIC) and education.
Further institutional novelties were the creations of Secretaries for social inclusion in the MCT and the secretary for productive inclusion in the MDS. The secretary for social inclusion in the MCT has so far concentrated its attention on raising the visibility of scientific-technological activities and training. The MDS Secretary’s focus in productive inclusion is much more focused on the how poor people and individual entrepreneurs get into formal labor markets. Both secretary have very small budgets and are highly dependent on parliamentary amendments as we’ll see below.

**Interests**

The interests manifested themselves around the legislation in Brazil, and the Innovation Law raised controversies since its beginning. Proposed during the second National Conference of Science, Technology and Innovation in 2001, the law found approval in 2004 and ratification in 2005.

Strongly influenced by the French Innovation Law (Kruglianskas and Matias-Pereira 2005, Koeller 2009), it aims at boosting university-firm relationship mainly through the facilitation of technology transfer and human resources transfer between research institutions and private firms and through a bigger autonomy to research institutions to manage public resources and to raise private funds (Invernizzi 2005). It also establishes regulations over intellectual property rights in the case of joint research projects between firms and research institutions.

According to Invernizzi, the main critics came from the scientific community, who argued that the law was subordinating public universities to market pressures and conceiving innovation in a narrow sense only related to the interests of the firms, and not in relation to social needs (Invernizzi 2005). Koeller criticizes that the law continues to promote linear and demand driven innovation policy as opposed to systemic approaches (Koeller 2009). A further bill, the lei do bem, is still subject to controversies about the incentives and tax subsidies of private R&D spending. Aiming to reform a previous law that granted tax incentives for R&D only after presenting an official proposal from the firm, this law intend to decrease the bureaucratic operating expense and grant the incentives directly. Big firms that deliver a more detailed tax declaration can receive the tax reductions whereas small firms who are only required to give a less detailed declaration have no access to these benefits.

The Sectorial Funds, the Law of Goods and the Innovation Law indeed were important steps towards the innovation perspective in S&T policy, but not to a systems perspective as it is biased towards supporting bigger firms. Despite directing the focus of S&T policy towards innovation, the Brazilian S&TI policy during Cardoso’s second mandate was not conducted in integration with industrial policies (Invernizzi 2005). Erber and Cassiolato, in their work from 1997 (having experienced, thus, only Cardoso’s first mandate), also add that this characteristic gives it a lack of structural perspective which, in case of the sectorial policies, can be noticed through the complete lack of priority in between the initiatives.

Public policy formulation in STI policy in Brazil is organized in national conferences that bring together academics, researchers, policy makers and other interested societal actors at the municipal, state and national levels. The first conference, in 2001, introduced the concept of innovation into the policy framework and resulted in
the green paper. This paper was a well articulated framework that clearly stated the need for enhanced innovative performance, although it was very much driven by actors from the public sector in academia and government.

The fourth conference in 2010 experienced a new dynamic. More actors from the academia, the private sector and the military participated in the process labelled as ‘Science, Technology and Innovation for sustainable development’. Ironically, 18 years after the 1992 World Earth Summit in Rio de Janeiro that introduced the concept of sustainable development, the concept made its way into the STI policies. This process is recent and ongoing. A Blue Book, Livro Azul, presents recommendations that show clear responses to the global changes and climate change. Measures to encourage the global competition to attract highly skilled researchers into Brazil, especially from Europe, are part of the recommendations.

Nevertheless, among these cross-cutting initiatives and regulations, in the budget allocations of this year, 21% are allocated to nuclear and space technologies, 4% social inclusion and 11% human resource training and capacity building.

**Graph 3 MCT Budget allocation 2010**

The budget share of the overall government budget allocated to MCT was 1%, and 4.023.579.077 Reais (~ 2.339.290.161USD) in total in 2010. But not all technological and innovative projects come out of this budget e.g. the government’s shares in PETROBRAS that just rose from 40 to 48% to increase the control over the deep water drilling technologies (PRÈSAL) and exploration of oil fields (FT 24.9.2010), are for innovation policies beyond the MCT’s reach.

Since 2003, Brazilian STI policy has an explicit focus on SI for social inclusion aligned to the Fome Zero/ Bolsa Família program, which is the most comprehensive transfer program for poverty alleviation. The Secretary for Social Inclusion in the Ministry for Science and Technology has established a series of interventions that mostly focus on making sciences more popular among the population and diffusion of
technologies in clusters. Since 2007 the government started setting up vocational training centers for STI (CVT) to enhance the level of scientific-technological skills in the clusters. The problem that CGEE states in its evaluation is the high dependence on parliamentary amendments. Only 7% of the Secretary’s funding comes from the Ministry’s regular budget. The rest comes from additional parliamentary grants depending on a deputy’s approval. Those have the intention to please the voters in their electoral district, where the CVTs are built. After the initial parliamentary funding the centers often turn into a burden for the municipalities’ budgets.

In South Africa, legislation is weaker. There are no tax relief rules for firms who invest in R&D or regulation for university researchers to allow them to work for private firms, as the innovation law or law of good in Brazil. The lack of this legislation derives from a lack in articulated demand. The funding programs that are available result from government driven intervention and create institutions for support as of the NRF, the innovation fund and nowadays TIA.

The systems approach adopted in the white paper, from the beginning has a strong commitment to value of human resources in socio-economic development. The 10 year innovation plan, written in 2007, reinforces the importance of human development in the transition towards ‘a knowledge based economy’ by defining ‘human resource development’ as one of the five ‘grand challenges’ until 2018. The 10 year plan intends to mainstream this priority in its own work, cooperation and across the government. On the flipside, a strong focus on ‘the top of the iceberg’ which is PhD production rather than training of technicians and engineers according to the economic needs makes the objectives unrealistic to achieve.

Although the new Minister brought her former advisory body into the DST from the former department of Education, the 10 year plan is still a plan that is not actively acknowledged in other departments and has not received any additional funding from treasury. Therefore the integration with higher education policies in achieving these educational targets is necessary.

The budget allocation in South Africa shows that R&D expenditure has been increasing since 2007. Nevertheless, over years a third of the R&D budget was spent on nuclear research for the Pebble Bed Modular Reactor, a project that was abandoned by former minister of public enterprises Barbara Hogan. This large expenditure, for a technology over decades can be interpreted as techno-nationalist state behavior according to the framework above.

Nuclear research is also back to the peak in Brazil. The MCT funds the reactor development project with 500 Mio USD over 7 years since 2009.

**Table 3: Overview of the results**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Brazil</th>
<th>South Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic social and poverty oriented policies</td>
<td>Support for smallest, small and medium sized enterprises; spin offs and start up of new</td>
<td>PRIME (FINEP), technological support SMEs (SEBRAE)</td>
</tr>
<tr>
<td>enterprises</td>
<td>Support of local innovation system in low income communities</td>
<td>APLs</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Research incentives and funding on development and poverty issues</td>
<td>--, decision up to individuals in the academia</td>
<td>SARCHI Chairs</td>
</tr>
<tr>
<td>Domestic technonationalist interventions in national firms</td>
<td>% of R&amp;D expenditure in public research institutions, vs. public firms, vs. more systemic programming targeting at whole value chain</td>
<td>Subsidy programs</td>
</tr>
<tr>
<td></td>
<td>Large budget allocation to public enterprises and state controlled prestigious technology projects (e.g. nuclear)</td>
<td>Nuclear research program, IPEN the overall government share of 48%, for PRESAL in PETROBRAS</td>
</tr>
<tr>
<td>Internationalization</td>
<td>Adoption of international concepts for policy framing; policy transfer</td>
<td>PADCTs, NIS approach, indicators, innovation law</td>
</tr>
<tr>
<td></td>
<td>Reactive policies to global (security/economic/financial) threats</td>
<td>Sectorial Funds, Outgoing development assistance</td>
</tr>
<tr>
<td></td>
<td>Strategic international cooperation</td>
<td>German- Brazilian nuclear cooperation, Chinese-Brazilian Space Program, Strategic South South cooperation, IBSA, Pro Sul, Pro Africa</td>
</tr>
</tbody>
</table>
7. Conclusions

The research presented in this paper is still in progress. Our research was devoted to the following questions: How do governments in developing countries perceive SI policy problems? How do governments set priorities on public policy intervention in SI under the conditions of high inequality and poverty? Do governments adopt conventional SI policy approaches or do new forms of policy intervention and policy innovation emerge? We have shared with the reader preliminary findings.

Both cases show that STI policies were highly influenced by the externalities that resulted from globalization and external actors from the early beginnings. In the Brazilian case, the influences in the transition from democracy were influenced by the World Banks loans, and the need for resources resulting from the monetary and financial crisis. In consequence, policies towards social development only started off late, and are still facing problems. Half hearted instruments and lack of resources still turn STI policy into a direction that benefits the established science and technology system in terms of the well situated universities in the main centres, and the bigger firms. Small firms receive assistance at technical levels, but those are not part of the current STI legal framework. The conflict between academic freedom on the one hand and legitimate state intervention to direct research agendas towards social needs divides academy and policy makers. Government could solve this problem through structures of bottom up, funding that have strong criteria towards social development measures. At the firm level, the associations could try and negotiate an allowance for innovative activities in small firms, that could be bound to a deadline of five years, where a first report could be presented to the ministry to apply for further funds. But this does not happen, as the interventions are led by the state and supply driven. The systemic approach remains a normative tool to legitimize a linear practice of innovation policy.

The role models both countries adapted to frame their policies are the OECD promoted innovation system approaches. The OECD, less than the UNESCO and the World Bank, managed to include South Africa and Brazil, among other LICs, into their forums and working groups. Both countries are subject to regular economic reviews. The South African government participated in a particular innovation policy review. The process of integrating the recommendations of the report is still ongoing.

Further clubs of industrialized countries have opened up and invited the LIC to their meeting, such as the G8. Brazil brought STI policy on the agenda of the G20. But many of these forums still remain either talk shops, or concrete projects without much policy exchange. The main reference points are so forth the OECD and the EU. The EU’s Lisbon strategy was at least for Brazil a reference point and a model to draft legislation for the innovation law based on the French law.

Although both countries are still recipients of official development aid (ODA), the amounts received are minimal to the overall budgets (1% in South Africa, and 0,12 % in Brazil in 2008) The amount of loans decreased in the Brazilian case since the 2000s and were paid back by 2005. In South Africa the World Bank granted, a surprising loan to build a coal fire plant, but without any research related component. The IMF granted one minor loan for the innovation fund in 2005.
In sum, the role of IO’s loans has changed from being existential as in Brazil in the periods of crisis in the 1980s, to competitors with normal private banks. Therefore, it is more the IO’s who seek to maintain the relationships with their member countries, such as the IMF who holds an office in Johannesburg although never granting a major loan. Simultaneously, the LIC also buy into the IO to enhance their power. Brazil now has own shares in the IMF and the World Bank. South African former minister of finance lead the commission of the IMF’s vote and membership payments reform.

Both countries pursue growing development co-operation programs themselves. South Africa maneuvers its program mostly through the African Renaissance and International Co-operation Fund. This fund has grown from under USD 7 million in 2003 to almost 40 million in 2008/09. The total resources in outgoing development cooperation, estimated at USD 61 million for 2006/07, flow mostly into the Southern African Development Community (SADC) (DFA; DAC 2010). Brazilian development assistance increased to USD 437 million in 2007, up from USD 365 million in 2006. These funds go mostly into multilateral cooperation, but also in the research cooperation programs PróSul in Latin America, and PróAfrica in mostly Lusophone Africa.

Although the linear supply led model of STI policy was predominant from its early beginnings, institutions change slowly. A system that served the interests of the elites over decades in academia, politics and public enterprises does not easily change, just because its label changes. But especially the international cooperation has changed, from the recipient to simultaneously own donor activities.

Despite the ‘innovation system’s norm, budget allocations continue to favour big technology and basic science project, although the social benefit may not necessarily be given. The PBMR is one example. In the South African case, the policies continue to benefit from main technology projects in space, automotive sector and nuclear research.

Occasionally, punctual policy innovation occurred. The Sectorial funds are an example copied by the Argentine government. Conceptually, the cluster and local innovation systems approach was adapted and rethought in Brazil. The so called ‘Arranjos Produtivos Locais’ (APLs) are nowadays a common policy approach used by the Ministry, the National Development Bank and the agency for small firm support (SEBRAE) to just mention a few. Social development and inclusion is not systematically mainstreamed in STI policy practice. The institutional arrangements remain additions to the business as usual. Without a visible commitment in the budget allocation, the interventions will remain subject to political interest, as in the Brazilian case given through the parliamentary amendments.

In sum, government struggle to bear a ‘double policy burden’ dealing with domestic security and poverty issues, basic service delivery in public health and education and simultaneously with competitiveness and innovation policy at the level of industrialized countries.

Despite its rhetorical prioritization of social development in modern STI policy, budget allocations still show a strong priority on large-scale state controlled technological development projects. The aspect of science, technology and innovation for social development has advanced a lot over the last years, but still concentrates on punctual interventions and institutions as opposed to a mainstream approach.
The growing efforts in multilateral and South-South cooperation show that political will concentrated on specific priorities can change funding institutions relatively quickly.

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Dr Subhan Khan making his presentation
Introduction

Geo-spatial Science & technology policy in India is evolving in phases and still in the process of emergence. Though Science & Technology (S&T) System in India includes various departments & ministries like: (i) Department of Science & Technology (DST); (ii) Department of Space (DOS); (iii) Department of Atomic Energy (DAE); (iv) Department of Biotechnology (DBT); (v) Department of Scientific & Industrial Research (DSIR), and(vi) Ministry of Earth Sciences(MES), first two are the major players in relation to geo-spatial S&T.

Science & Technology Policy Instruments (STPI) after Independence


However, first time in 1991, measurers to make available geo-spatial data to users were elaborated in the Information Technology (IT) Policy and later on in 2005 Indian government took a historic decision by announcing and adopting a full-fledged policy called, ‘‘New National Map Policy (NNMP)” which had the potential to open a new door of opportunities for various sectors ranging from water management to development planning and infrastructure.

New National Map Policy (NNMP)

The NNMP (2005) was evolved by the Ministry of S & T, GOI, realising that global technological upheavals have rendered many features of the existing Map Policy of India redundant. The NNMP envisages separating the sensitive, security-related maps from the ones which can be accessed, used and even modified by the public. Hence this policy comes out with two series of maps-

(i) The Defence Series Maps (DSMs), for exclusive use for defence forces and authorized govt. departments, and

(ii) The Open Series Maps (OSMs), for public use, which however have a different datum, projection, content and sheet numbers and are derived from the National Digital Topographical Database (NDTD) of Survey of India (SOI).
Under new map policy, it was decided that for map dissemination, in digital or analogue form, SOI may enter into an agreement with any agency for specific end users for developmental planning, infrastructure and research community, etc. In addition, the user agency can also make value addition to these maps and with involvement of SOI, can share the information. It was also decided that all serial photographs after masking of Vulnerable Areas/Points will be freely available for processing and project generation. Further, a decision was also taken that private agencies will also be permitted to carry out surveys in all parts of the country using Public Domain Datum. In this way, continuance of this policy tends to impede free flow of spatial information and engenders high opportunity costs for a developing economy like India.

**Ontology of geo-spatial S&T**

Globalisation has led to the development of ontology of geo-spatial S&T, particularly in the fundamental ideas, geospatial data acquisition, visualization, storage, analysis, development of scenarios, modelling, DSS and dissemination, etc. Development in other science discipline includes spatial cognition, databases, statistics, data mining, computational geometry, vision, robotics & graphics, etc.

All these in fact intensified relations between different parts of the globe and also have highlighted the need for understanding and managing phenomena at various levels. The availability of technologies & facilities like internet has empowered to capture increasing quantities of information & communicating the same more effectively over vast distances across land, sea, air and space globally.

Consequently, in the past few decades, an increasingly wide range of geo-spatial technology tools, geospatial data and geospatial services have become available to a wide range of users including defence, civil governments, non-governmental organisations and multinational enterprises. Now a days, in fact, use of geospatial technology becomes mainstream, thus mandatory in most of the decision support systems.

**Dynamic Policy Framework for Geo-spatial Science & Technologies**

Thus a dynamic policy framework for geo-spatial science & technologies is needed to be devised and adopted by all the nations, small or big, developed or developing, as per their requirements. In the present era, the application of geo-spatial technologies in a few specific areas like national security, counter terrorism, counter insurgency, disaster management, natural resource management, developmental planning etc. made these more relevant and necessary for all the countries and regions of the globe.

Policies which talk about a network-centric approach utilizing state-of-the-art of such technologies and also encourage open standards that apply to both the data exchange protocols and the data formats, etc. may be of much use in this context.

**Open Geospatial Consortium (OGC) & OpenGIS**

Very recently, the most revolutionary development which happened in this field is existence of the Open Geospatial Consortium (OGC), which came into existence in 1994 under the Chairmanship of Dr David Schell. Dr Schell as founding Chairman of the Board of Directors remains as one of the geo-spatial S&T leader and garnered both public and private sector support for “OpenGIS®” into a global standard and for interoperable geo-processing.
In India, Dr. (Brig.) R. Siva Kumar is the CEO of National Spatial Data Infrastructure (NSDI) and also Head of the Natural Resources Data Management Systems (NRDMS), a division of DST that are spearheading NSDI development in India. In his role as Member Secretary of the Task Force on NSDI he bore primary responsibility for launching the NSDI movement in India.

The above is a brief description of systematic account of the various developments and evolution process of Geospatial Science & Technology Policy of India and their dissemination in a range of disciplines including studying their impact on the society.
Dr (Mrs) Sunita Garg
NISCAIR–The CSIR’s Scientific Information Resources for Science and Society

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Abstract

National Institute of Science Communication and Information Resources (NISCAIR), a constituent of CSIR, has been involved in dissemination of information through the publication of 19 scholarly journals of international repute, 3 popular science magazines (Science Reporter, Science-ki-Duniya and Vigyan Pragati in commonly known languages like English, Urdu and Hindi, respectively), books, training courses, various information services, etc. covering all the major disciplines of science and technology. NISCAIR, the erstwhile PID and NISCOM is in the service of the nation for the last more than 50 years. In the fraternity of CSIR laboratories, NISCAIR has a special, and a very important mandate- that of providing a platform to scientists and researchers for communicating scientific achievements for the development of science for society globally. Further to communicate scientific achievements and issues of topical concern and inculcate scientific approach in young and innovative minds, the next major jump in NISCAIR’s services to science and society is the online open access availability of its scholarly research journals and magazines. NISCAIR is a proud nodal centre for implementing CSIR e-journals Consortium, a major network project of CSIR. NISCAIR’s focus on assertive talent development through the Associateship in Information Science (AIS) programme continues to find favour with students of MBA, B. Tech, MCA, M.Sc, M. Lib, etc. National Science Library (NSL), NSDL, NUCSSI, Indian Patent Database, Bibliometric services and RHMD are some other information products and services which this institute is providing to the science and society.

Since 1942 NISCAIR has been a custodian of The Wealth of India—an encyclopaedic publication on plants and animals biodiversity and mineral resources of India which is a ready reckoner on natural resources for researchers, entrepreneurs, students and policy planners. Concerted efforts are made to revise and supplement the information to keep it updated. Accordingly, original 11 volumes are now available in total 23 volumes encompassing monographic articles on more than 6000 indigenous plant species, 50 on animals and 73 on minerals of economic importance.

SAARC Documentation Centre (SDC), set up in 1994 at NISCAIR is continuing its activities to fulfill its objectives to disseminate S&T information among SAARC member states. NISCAIR is a recognized study centre for MCA, MLISc and BLISc of IGNOU sponsored programmes. Graphic art and print production division is the backbone of NISCAIR which is supporting not only in-house but consultancy jobs received from many Government and private agencies. The division is maintaining its own printing press in the premises and doing single as well as four colour jobs.
Introduction

National Institute of Science Communication and Information Resources (NISCAIR), a constituent of CSIR came into being on 30 September 2002 with the merger of two establishments of the CSIR family, namely, National Institute of Science Communication (NISCOM) and Indian National Scientific Documentation Centre (INSDOC). The erstwhile NISCOM came into being with the renaming of the Publications and Information Directorate (PID) in 1996.

NISCAIR is in the service of science and society with a mission to become the prime custodian of all information resources on current and traditional knowledge systems in science and technology in the country and to promote communication in science to diverse constituents at all levels, using the most appropriate technologies. The institute is now functioning with following main mandate:

- To provide formal linkages of communication among the scientific community in the form of research journals in different areas of S&T.
- To disseminate S & T information to general public, particularly school students, to inculcate interest in science among them.
- To collect, collate and disseminate information on plant, animal and mineral wealth of the country.
- To harness information technology application in information management with particular reference to science communication and modernizing libraries.
- To act as a facilitator in furthering the economic, social, industrial, scientific and commercial development by providing timely access to relevant and accurate information.
- To develop human resources in science communication, library, documentation and information science and S&T information management systems and services.
- To collaborate with international institutions and organizations having objectives and goals similar to those of NISCAIR.

Over the years many new activities have been added with due respect to mission and mandate. NISCAIR is performing its following major activities and reaching out to the national and international scientific community and catering to the information needs of science students and entrepreneurs.

Dissemination of S & T Information

NISCAIR endeavours to serve research scientists globally by providing communication links through 17 primary scholarly journals in Biological/Life Sciences, Chemical / Physical Sciences and Library Sciences, 2 abstracting journals and one electronic repository on Natural Products and Resources. Out of 17 research journals 9 are covered in Sci-Database. All research journals, published by NISCAIR follow
international practices i.e. all are peer reviewed. Efforts have been made to obtain e-ISSN for all the journals available online and all journals have also been registered in the Directory of Open access Journals (DOAJ) (http://www.doaj.org/doaj).

The special features of NISCAIR journals are:

i. No page charges are realized from authors.

ii. Authors can liberally provide coloured plates, graphs.

iii. Good quality paper is used for printing.

iv. To protect the priority of publication and to prevent plagiarism it is mandatory on the part of authors that at the time of submission of the paper they should provide a certificate of declaration that the paper submitted for publication is original and has not been submitted elsewhere and also that proper citations to previously reported work have been given and no data/tables/figures have been quoted verbatim from other publications without giving due acknowledgement.

v. All the journals publish guest edited special issues on contemporary thematic topics from time to time.

vi. Full text of all the papers published in NISCAIR journals available online at the NISCAIR Online Periodicals Repository (NOPR) (http://nopr.niscair.res.in). Efforts have been made to obtain e-ISSN for all the journals available online.

vii. All the published papers and abstracts have been made searchable.

viii. All the journals are being covered in leading abstracting and current awareness services, hence the visibility and citation of papers are undoubtedly increasing every year. Recently NOPR has recorded 80030 total visits on its home page from more than 121 countries.

ix. The downloads of full text articles (pdf files) is more than 15, 19, 302.

x. Process for online submission, acknowledgement, status, etc. is in progress.

Science Popularization

NISCAIR is committed to take science to society particularly young talents. Three well-known science magazines: Science Reporter (English), Vigyan Pragati (Hindi), Science-Ki-Duniya (Urdu) are attempting to provide current as well as theoretical science knowledge to society in simple, lucid and illustrated commonly written and spoken languages.

Under its science popularization mandate, NISCAIR has also brought out large number of popular science books, which remain much in demand. CSIR News and CSIR Samachar are the two newsletters which help in making the society aware of CSIR organization’s activities and accomplishments.

Information Resources

One of the core activities of NISCAIR is to collect, organize and disseminate S & T information generated in India as well as in the world. The institute possesses comprehensive collection of S& T knowledge in print as well as in electronic form and
databases that could be of immense benefit to different segments of the society. Given below are some of these information resources:

1. The Wealth of India
2. Bharat ki sampada
3. Raw Materials Herbarium and Museum
4. National Science Digital Library (NSDL)
5. National Science Library (NSL)
6. CSIR e-Journals Consortium
7. National Union Catalogue of Scientific Serials in India (NUCSSI)

1. The Wealth of India

*The Wealth of India,* launched in 1942 is an internationally acclaimed encyclopaedic publication comprising monographic articles on plants, animals and mineral resources of the country and the economic products derived from them. The encyclopaedia is a continuation of George Watt’s Dictionary of Economic products of India. Policy-planners use the information to prevent bio-piracy. It has in recent past played a major role in preventing the US patent on turmeric.

The encyclopaedia, aptly named The Wealth of India amasses the renewable resources of the country including the rich biodiversity of plant and animal species as also the mineral wealth abounding in the Indian subcontinent. The plants are dealt with under their generic and specific names but articles on animals appear under the English names and minerals with their English names or scientific equivalents at appropriate places. There are also some polymerous entries, such as Algae, Bamboos, Corals, Fungi, Insects and Insect pests, Prawns, Shrimps and Lobsters, etc.

Correct identity of each plant has been ensured, its distribution in wild or occurrence as cultivated plant in India is provided, and the parts of economic importance have been adequately described. In the case of crop-plants, methods of cultivation, harvesting and storage are given, diseases and pests and their control measures are also mentioned. The zoological entries give the habits and habitat of the animals, their status and important products derived from them. Regarding minerals, their occurrence and distribution in the country and methods of exploitation and utilization are given.

The main series consists of 11 volumes and 2 supplements: Fish & Fisheries and Livestock including Poultry. An exhaustive cumulative index in 4 parts, viz. botanical names, zoological names, active principles and other important compounds and names in regional languages, trade-names and common English names, covering more than 250 pages, is appended to the final volume. This cumulative index is immensely useful to users in locating the entries by scientific, trade as well as common English and vernacular names in available regional languages.

For facilitating easy access to information, each volume includes features such as cross-references, lists of books and journals cited and a meticulously made index of the
synonyms of plants dealt with, cultivars of crops, common English, vernacular and trade names, drugs, products, active principles and important chemical compounds. Adequate references to the sources of information are provided at appropriate places, and the articles are well illustrated with halftone and coloured plates, line-drawings, charts, maps, etc.

In addition to 11 volumes of main series, 3 revised and updated (A, B and Ca-Ci alphabets) plus a supplement on Bird has been brought out. The revised volumes boast of an elaborate use based index as an additional feature. Subsequently, supplements (covering information from 1982-1996) have been brought out in 8 volumes maintaining the style and format of the parent series and every effort has been made to give a cohesive presentation so as to easily blend with the parent volumes.

The complete set of 23 volumes of The Wealth of India-Raw Materials series is much sought after as a ready reference for its extensive, authentic coverage on distribution, cultivation, production, diseases and pest control measures, harvesting and post harvesting care, chemical composition, utility including community knowledge, conservation, statistical data, etc., especially in the search for natural resources in the life of living beings in broader prospective. Compiled and collated by a body of subject experts with the collaboration of specialists in various fields all over the country, the entire work is a treasure house of knowledge on any natural raw material information.

The Wealth of India is indispensable to research workers especially beginners dealing with life sciences, chemical sciences, pharmacology, environmental sciences, students of economic botany, government departments and rural development agencies, planners, industrialists and all those interested in the availability of Indian raw materials, their production, value addition, exports and imports.

The complexity, heterogeneity and voluminousness of this encyclopaedic work can be visualized from the fact that whole series covers more than 6000 plant-species, 52 articles on animals and their products and 73 articles on minerals. The diversity of information stored in various volumes and current literature compiled for supplements of this encyclopaedia, has led us to select some common wild plants which possess insecticidal activity against Aedes aegypti and distribute it as an extension bulletin to scientists, entrepreneurs, students, NGOs and others during the International Year of Biodiversity 2010 for further research.

The literature revealed that in addition to traditionally and commercially used repellants, larvicides, oviposition inhibitors and mortality products based on Pyrethrum (Chrysanthemum cinerariaefolium (Trev.) Bocc., Persian Lilac (Melia azedarach Linn.), Neem (Azadirachta indica A. Juss.), Tulsi, Holy Basil (Ocimum sanctum Linn.), 30-40 plant extracts are reported to be effective against, dengue vector. Almost all these herbs, shrubs or trees are easily available and have shown 60-100% mortality against III/early IVth instar larvae and complete lethality at minimum doses. Some recently reported insecticidal plants effective against Aedes aegypti and found growing throughout the year in waste places, garden hedge, or in open fields are enlisted below: are
Country Mallow, Hindi- Kanghi, *Abutilon indicum* (Linn.) Sweet

A shrub with small orange-yellow flower. It is common all over in hedges and waste places as a weed. The petroleum ether extract of the plant showed larval mortality (57%) after 24 hours exposure. The chemical compound, β-sitosterol, identified for the first time in this plant has been found to be a potential new mosquito larvicidal compound.

Bitter apple, Colocynth, Hindi-Indrayan, Gadumba, *Citrullus colocynthis* (Linn.) Schrad.

A perennial trailing herb bearing deeply 3-lobed leaves and yellow flowers. Grows commonly in sandy soil. Fruit is used medicinally for stomach disorders. Larval mortality has been found in whole plant petroleum ether extract after 24 hour exposure.


An erect undershrub. Leaves large, ovate; flowers greenish-white. Common in waste places, a troublesome weed when in fruits, due to its spiny bracteoles and pointed tepals. Larval mortality has been found in the ethyl acetate extract of the plant after 24 hour exposure. The plant also possesses many medicinal properties.

Milk bush, Hindi-Sehund, *Euphorbia tirucalli* Linn.

An unarmed shrub or a small tree with erect branches and smooth, cylindrical branchlets, naturalized in South India and grown in hedges throughout India. The insecticidal property of the plant was tested against the early fourth instar larvae of *Aedes aegypti* Linn. The larval mortality was observed after 24 hour of exposure. All extracts showed low larvicidal effects; however, the highest larval mortality was found in petroleum ether extract. The \( LC_{50} \) value of petroleum ether extracts of *E. tirucalli* was 4.25ppm. It is, therefore, suggested that this plant can be applied as an ideal potential larvicide against *A. aegypti* as ideal ecofriendly approach for the control of the dengue vector.

Eupatory, Sticky snakerooot, Catweed, Croton weed or Mexican devil, *Ageratina adenophora* (Spreng.) King & H. Rob.

It is a perennial herbaceous exotic shrub which may grow up to 1 or 2 m height. It has opposite trowel-shaped serrated leaves that are 6-10 cm long by 3-6 cm in width. The small compound flowers occur in late spring and summer, and are found in clusters at the end of branches. Each flower head is up to 0.5cm in diameter and creamy white in colour. They are followed by a small brown seed with a white feathery 'parachute. Found in the hilly regions of the Nilgiris district as weed plant. The \( LC_{50} \) value of its extract was found to be 356.70 ppm for *A. aegypti* and when compared to neem, the leaf extract of this plant is more toxic to both *A. aegypti* and *C. quinquefasciatus* and could be effectively used for the control of mosquito larvae.
**Lantana, Lantana camara Linn.**

A straggling or climbing, aromatic spiny shrub, found throughout India in varied flower colours in waste places or as garden hedge. The methanol extract of its flowers along with coconut oil has been found to be dengue mosquito repellent. The leaf extract also showed larvicidal efficacy. Lethal concentration of leaf extracts were 203.49ppm.

**African marigold, Hindi-Genda, Tagetes erecta Linn**

Commonly cultivated in gardens for its ornamental orange or yellow cut flowers and beautiful dissected foliage. Acetone extract of the plant and steam distillated essential oil has shown larvicidal activity.

**Black nightshade, Hindi-Makoi, Solanum nigrum Linn.**

Branched erect or diffuse herb with white flowers, well known for its medicinal properties. Common in waste places and cultivated fields especially in shady places. Crude leaf extract possesses larvicidal activity.

**Bracteated birthwort, Hindi-Kiramar, Aristolochia bracteolata Lam.**

A glabrous prostrate herb bearing dark purple flowers. It is extremely bitter plant, found in Delhi throughout the year. The roots of the plant are used as a substitute for *Aristolochia indica* Linn. (Hindi-Isarmul, Indian Birthwort) roots which yield aristolochic acid, used as an insecticide. The aristolochic acid is reported to be toxic to adult *Aedes aegypti* mosquitoes.

**Madar or Ak, Calotropis procera (Ait.) R. Br. and Calotropis gigantea (Linn.) R. Br. ex Ait.**

Both the species are found throughout the year in waste, sandy and dry places and are used similarly. An erect shrub bearing purplish-red, pale silvery outside flowers. All parts of the plant yield latex which is highly toxic to animals in large doses. The latex has shown strong ovicidal and larvicidal activities against *Aedes aegypti* and other mosquitoes.

**Red Periwinkle, Hindi- Sadabahar, Catharanthus roseus G. Don**

A beautiful plant found growing in gardens and as wild also. It is highly medicinal plants for various diseases especially known for anticancerous properties. The alcoholic extract of the shoot showed larvicidal activity against *Aedes aegypti*.

**Milfoil, Yarrow, Hindi- Gandana, Achillea millefolium Linn.**

Aromatic herb, distributed in Himalayas from Kashmir to Kumaun at 1,050-3600m. Its flowers are white or pale pink. In Himachal Pradesh this herb is very common during May and June. It is also cultivated because of its high medicinal value. The ethanolic extract of the plant showed mosquito repellent activity against *Aedes aegypti*.

**Carrot, Hindi-Gajar, Daucus carota Linn.**

The seed oil of the common vegetable carrot is reported to be toxic to *Aedes aegypti* and *Culex fatigans*
Christmas flower or Poinsettia, *Euphorbia pulcherrima* Willd. ex Klotz.

A garden shrub bearing bright vermilion-red or crimson-bracteal leaves, planted in hedges. The leaf extract is reported to reduce the adult emergence of *Aedes aegypti* larvae significantly.

**Congress grass, Gajar grass, Parthenium hysterophorus** Linn.

The congress grass found throughout the country as a weed possesses useful properties also. Petroleum ether extracts of its leaves, stem and inflorescence at 500, 1000, 2000 and 5000 ppm concentrations showed toxic effects on the mean life span and progeny production of adults of the mustard aphid. Further studies revealed that it also has larvicidal activity against *Culex quinquefasciatus*, *Anopheles stephensi* and *Aedes aegypti*, i.e. it can work against all three mosquito species causing malarial as well as dengue fever.

**Prickly poppy, Hindi-Kateli or Satyanashi, Argemone mexicana** Linn.

A robust herb, leaves prickly, flowers yellow, capsules erect, spiny, seeds black, look like mustard seeds. It is common in waste places, fallow fields and roadsides. The acetone fraction of the petroleum ether extract of seeds exhibited larvicidal and growth inhibiting activity against the second in star larvae of *Aedes aegypti* (Linn.). This activity occurred at higher concentrations (200, 100, 50 and 25 ppm). Chemosterilant activity, including reduction in blood meal utilization (27.70%), reduction in fecundity (19.00%), formation of larval-pupal intermediates, formation of pupal-adult intermediates, adult mortality and sterility of first generation eggs (100%), occurred at low concentration (10 ppm).

**Jatropha curcas** Linn., *Pedilanthus tithymaloides* Poit., *Phyllanthus amarus* Schum. & Thonn., *Euphorbia hirta* Linn. are also weeds and their petroleum ether extracts have also showed low larvicidal effects on fourth instar larvae of *Aedes aegypti* after 24 h of exposure.

2. Bharat-Ki-Sampada

*Bharat Ki Sampada- Prakritik Padarth* is a scientific encyclopaedia of raw materials in Hindi language. This encyclopedia, launched in 1969 is the Hindi version of Wealth of India- Raw Material series.

3. Raw Materials Herbarium and Museum

The Herbarium and Museum of Economic Raw Materials was set up in 1978 as an adjuvant to Wealth of India to represent the plants, animals, minerals and their economic products dealt with in the Raw Material series of the encyclopaedia. Over the years it has diversified its activities and received acronym, ‘Raw Materials Herbarium & Museum, Delhi’ (RHMD) from INDEX HERBARIORUM, a constituent establishment of the International association of Plant Taxonomy (IAPT), New York Botanic Garden, New York, USA. Presently it houses authentic 8000 plant specimens, 190 zoological specimens, 207 mineral samples and 2500 carpological samples (roots, seeds, bark, wood, flowers, etc.)
Herbarium Techniques training, Consultancy services and Exhibition

Every year RHMD is organizing a training/workshop programme on Herbarium techniques and providing basic knowledge pertaining to systematics to researchers, traders, students, crude drug dealers, and entrepreneurs. A consultancy service in identification of plant-based crude drugs and herbarium specimens against payment of moderate fee is being offered.

4. National Science Digital Library (NSDL)

The NSDL aims at providing comprehensive S&T information through internet access to undergraduate students of science, engineering and Technology in the country. Over 512 modules pertaining to 19 disciplines have been finalized and posted on NISCAIR website.

5. National Science Library (NSL)

NSL possesses a comprehensive collection of S&T publications and offers services on a national scale. NSL subscribes to almost all Indian S&T periodicals and 350 foreign journals. In addition to its services to S&T community, it provides support to other activities of NISCAIR like, Indian Science Abstracts, Medicinal and Aromatic Plants abstracts, Wealth of India and providing contents, abstracts and photocopy services (CAPS), Document Supply Service, etc.

6. CSIR E-journal Consortium

The CSIR e-journals consortium, a major network project of CSIR is being implemented by NISCAIR, has recently made agreements with 26 international publishers for enabling online access to 4400 + electronic journals apart from various databases and standards to CSIR scientists, thus enriching their knowledgebase and giving them an edge in scientific research.

7. National Union Catalogue of Scientific Serials in India (NUCSSI): This catalogue was brought out by the then INSDOC. Now it has been updated and made available on NISCAIR website. It contains more than 44,736 titles of journals available in about 540 libraries.

Business development

NISCAIR has an active Sales and Marketing Division to promote the reach and increase the subscriber base of journals and sales of books published by NISCAIR through locating new markets, sending complimentary copies of journals, brochures, attending book fairs and exhibitions and others.

Human Resource Development

NISCAIR is equipped with the necessary facilities and manpower to obtain and prepare science communicators, R&D personnel and library and information science professionals for meeting the challenges of the current times. Some major activities under this programme are:
**Associateship in Information Science (AIS):** The course objective is to train the students in techniques of information handling and management with special emphasis on application of information technology for designing, implementing, operating and managing information systems. An important feature of this two–year course is the periodic holding of colloquia and seminars, which provide opportunities to students for debating, articulation and collective thinking. The students of this course are allowed to participate in other short-term courses conducted by NISCAIR.

**Short-Term/Attachment Training Courses:** NISCAIR conducts short-term trainings on contemporary topics like: Design and Development of Digital Libraries using DSpace, information technology for information management, library automation, bibliometric tools and techniques, technical writing and editing, science communication and science popularization, patent drafting, etc.

**Training /Workshop on Herbarium Techniques:** The workshop covers latest scientific methods of collection of plants and their identification, imparting knowledge of nomenclature, processing of herbarium collections, etc.

**Services**

**Production, Printing and Graphic Arts Services:** To fulfill its mandate NISCAIR publishes high-quality S&T literature with mass appeal. NISCAIR possesses vast paraphernalia of pre- and post-press facilities and expertise in the field of print production.

In addition to in-house jobs of publishing journals, newsletters, magazines and encyclopaedia, the print production division of NISCAIR undertakes outside jobs of 2 or 4 colour production, graphic design and printing work from CSIR labs, institutions and other Govt departments.

For publishing books NISCAIR’s subject experts evaluate the manuscript and approve its suitability for publication from the point of view of scientific contents and its applicability. On the approval of the manuscript by the committee it is given to subject expert at NISCAIR for editing and follow up work.

**CAPS:** The main objective of Content, Abstracts and Photocopy Services (CAPS) is to fill the gap created by sharp decline in the availability of foreign periodicals to the Indian S & T Community. This service is of great help to scientists who do not have access to foreign periodicals. On a yearly subscription, one can get contents of journals of one’s choice from about 7300 Indian and foreign periodicals pertaining to different disciplines on paper, diskette or through E-mail. On browsing the contents, one can place order for abstracts and /or photocopies of full paper.

**Bibliography:** NISCAIR provides comprehensive bibliographies on any topic in any discipline of science and technology by searching periodicals, patents, standards, technical reports, conference proceedings, business and market information of products.

**Reader’s service:**

NSL is open to public for reading and consultation during working hours and also on Saturdays. On the spot photocopy facility is also available on nominal charges.
**ISSN services:** NSL is the ISSN National Centre among a network of over 80 national Centres worldwide. It is responsible for assigning ISSNs free of charge to serials published in India. The centre is also responsible for contributing Indian records to the world database of ISSN numbers, known as the ISSN register, maintained by ISSN international centre in Paris.

**Informetrics research:** Informetrics research section provides scientometric analysis of research papers on individual scientists and institutions, impact factor calculation and detailed analysis of research papers of academic and research organizations.

**Document Procurement and Supply:** To meet the requirements of researchers and scientists in the country, Document Procurement and Supply service is being offered by NISCAIR from its own collection of about 5000 periodicals and from other libraries also. NIACAIR procures the desired document from foreign sources.

**Foreign language services:** NISCAIR is providing translation services from foreign languages to English and vice-versa. Interpretation service in Japanese is being rendered by NISCAIR effectively.

**Advertisements:** Commercial advertisements related to scientific publications, equipment, technologies, competitions, seminars, awards, etc. are taken up for publication on the payment basis.

**Saarc documentation centre (sdc)**

SDC at NISCAIR was set up for regional co-operation and exchange of information in the field of science, technology, industry, trade, commerce and development matters. In addition human resource development in library and information science is also arranged for the candidate nominated by SAARC member countries. SDC is maintaining a library of books and journals published in the region and on various developments in various regions. A newsletter is being published regularly from SDC.

**Conclusion**

Seeing the facilities and expertise available at NISCAIR, the researchers, scientists, entrepreneurs, NGO and students are most welcome to visit NISCAIR website for detailed information. Research papers, books, proceedings, annual reports, etc. can be communicated for publication. The bibliography, patent search, patent filing and any other related document is available to accomplish a innovative research in India. Collaborative projects to start R& D and databases in the fields of Biodiversity and Bioresources are most welcome.
Parliamentary Session
Prof. Saifuddin Soz, Hon. Member of Parliament (Rajya Sabha)

Hon. Shri S.S. Ramasubbu, Hon. Dr. Narong Boonyasaguan, Hon. Shri Ganesh Shah, Dr. Lidia Brito, Hon. Prof. Saifuddin Soz
A message from Dr. A R Kidwai, Chairman, Zaheer Science Foundation, who was indisposed, was read out by Dr. Shahid Siddiqui, Section of Pulmonary & Critical Care Medicine, Pritzker School of Medicine, University of Chicago, USA. In his message Dr. Kidwai welcomed the participants, emphasised the need for deliberations on the Conference theme and looked forward to their comments and suggestions.

Dr. Lidia Brito, Director, Science Policy Division, UNESCO, Paris, expressed her satisfaction about the internationally wide-based representation and participation in the Conference. It was important to communicate the S&T practitioner’s perspectives to parliamentarians and policy-makers, despite the differences in practice and policy. A multi-disciplinary approach is essential. S&T have wide impacts on society. There is need to provide more space to social and peoples perspectives in S&T policy formulation and implementation. UNESCO encourages and facilitates such interactions. The efforts by Zaheer Science Foundation and Dr. Mohsin U Khan, Secretary, Zaheer Science Foundation, in this direction are commendable.

Dr. Ninlawan Petcharapuranin, Senator of the Standing Committee on Science & Technology, Communication and Telecommunication, Thailand, presented a comprehensive brief overview of S&T policy formulation in his country. This included : The composition of the Senate; relevant S&T committees, their legislative authority, recommendations, duties, powers and supervisory administrative responsibilities; ranking in terms of S&T indicators; and sector wise R&D. The social-developmental issues of concern are: climate change, renewable energy sourcing, emerging diseases, ageing population, local community involvement and regional innovation systems among others. The S&T scenario over the next 10 years and manpower and budgetary implications were presented.

Mr. Narong Boonyasaguan, Advisor to the Standing Committee on Science and Technology, House of Representatives, Thailand, outlined the role and responsibilities of Parliamentarians in development with specific reference to S&T initiatives in Thailand. Standing Committees and Sub-committees of Parliament strategically focus on core issues of development of economy and society in general and biotechnology, advanced and alternative technology and Energy Environment in particular, based on national vision and missions. The latter include: enhancement of R&D capacity; advice to public and private sector; technology transfer to SMEs, legal and regulatory provision for technology commercialization, monitoring of program etc. Besides, Thailand was pursuing technology and policy cooperation with her neighbours in Indo-China, and with USA and Japan, especially in respect of natural disaster management and climate change.

Prof. Saifuddin Soz, Member, Rajya Sabha (Upper House of Parliament), India, highlighted the importance of S&T in National development. He offered to facilitate scientists’ interaction with more of knowledgeable and involved Indian Parliamentarians.

Shri S. S. Ramasubbu, Member, Parliamentary Standing Committee on Science and Technology, Govt. of India, observed that S&T can contribute to the development of
all sectors. GOI, UGC, CSIR, among others, were actively promoting such development, especially in IT, healthcare etc. However, many unresolved issues related to economic and social impacts of Climate Change need to be addressed by scientists and policy makers. Younger people need to be encouraged to take up careers in science with a human face.

Dr. Paula Tiihonen, Committee Counsel to the Committee for the Future, Parliament of Finland, informed about her country’s efforts to prioritize major S&T problems and issues and to suggest their resolutions.

Mr. Avudh Ploysongsang, Adviser to the Standing Committee on Science and Technology, House of Representatives, Thailand, highlighted the uneven distribution of benefit from new technology, especially GMCs. Government was too busy and relatively ignorant of the economic and social impacts of new technologies across sectors and regions. He proposed a high-ranking national chief technology officer, supported by elected representatives, to better inform the parliamentarians and decision makers about the causes and outcome of technological developments, especially in respect of food security and poverty.

Dr. Aqueil Ahmad, Core Faculty, School of Management, Walden University, North Carolina, USA, proposed on the basis of informal discussion with the participants, that the networks created by this and preceding biennial Conference on S&T may be formalized into a permanent International Forum, for continuing interaction among S&T practitioners and policy makers, supported by UNESCO, ZSF among others. To broaden such interaction, he suggested that next biennial S&T Conference in 2012 may be held in Petersburg. This suggestion was warmly welcomed by Dr. Svetlana Kirdinia, Institute of Economics, Russian Academy of Sciences, Moscow, Russia. Dr. Lidia Brito informed that UNESCO was supporting international and regional forums on S&T. She suggested that the present networks may link up with the UNESCO supported Budapest Global Forum. There was also a need to promote effective S&T dialogue at national levels and across regions.

The panel discussions which followed were about: how S&T Initiatives can help poverty alleviation; how to bring about greater social consciousness, civil responsibility and morality in S&T; how to address socio-economic challenges arising from demographic changes; how to identify good and bad S&T policies and practices; how to get parliamentarians to give more priority to S&T, without politicizing the scientists; how the Parliamentarians can deal with issues arising from the inflow of MNC’s etc. The responses from the Panelists were: Scientists should not be politicized; needs of the elderly, alternative energy sources, and forest and environment should be addressed; Scientists should effectively and vibrantly communicate with policy makers on socio-economically relevant impacts of S&T. S&T should address development of SMEs. S&T should be bottom-up, not top down, and democratically, socially and morally accountable.
Concluding session: “Building Bridges through dialogue between Parliamentarians, Scientists, Media and Society

Dr. P Banerjee, Director, NISTADS, New Delhi, highlighted the role of scientists, parliamentarians and administrators, as their decisions impact down to the village level. S&T should contribute to more accessible and cheaper provision of public services.

Dr. Diana Malpede, UNESCO, historically traced the evolution of S&T policy since World War II. New and serious challenges have emerged during the current decade. Promoting dialogues and building bridges among scientists and policy makers are essential.

Ms Chandrika Nath, Parliamentary Office of Science and Technology, UK, stated that the awareness of Parliamentarians on S&T and related development concerns was very low. Scientists can help overcome this lacuna through information and advice.

Dr. N P Singh, Adviser, Ministry of New and Renewable Energy, Government of India, New Delhi, highlighted the development of renewable energy, including solar, biomass, wind, micro-hydel etc.

The session ended with some discussion and concluding remarks by the Chair.

Special recommendations were read out by Dr. Mohsin U Khan, Coordinator of the Conclave which are following:

- There should be an Asia network of science policy researchers to interact among themselves and exchange information from time to time.
- The above network could organize training programs and workshops on science and technology policy and other related areas.
- The South Asian and South East Asian researchers could work out research programs on regional cooperation.

A big Conclave of scientists should be organized every year at different places in South Asia and Southeast Asian countries

Closing Remarks by Senator Dr. Nilawan Petcharaburanin

“It is an honor to be a part of the Conclave under the title ‘Regional cooperation in Science & Technology: Opportunities and Challenges in the context of Globalization’. This is quite an auspicious event. We have gathered people from all over the world, who are not only knowledgeable in science and technology but also considerate to the world we are living. We have addressed the essential global issues of climate change, science and technology and innovation policy, health service: developments in science and economics, impacts of science and technology on society, innovation management and technology transfer, and information and communication technology. This Conclave has given us a promising opportunity in utilizing science and technology at its best. We have successfully pioneered in unifying the ultimate solutions for making our world a better place. Because this planet belongs to all of us, we need to bring the world together as one. Thank you everyone for your great dedication to make this happen”.

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Address by Dr. Lidia Brito in the parliamentary session

Director,
Science Policy and Sustainable Development Division,
UNESCO, Paris

Excellencies,
Ladies and Gentlemen,

The world today is moving towards multi-polarity and economic globalization is gaining momentum, accompanied by rapid progress in science and technology and ever-closer regional cooperation. We are all convinced of the complementarity between the global and the regional dimension of cooperation. Science cannot be international without the active involvement of scientists from all parts of the world in the scientific endeavour and in setting the research agendas, and also that international cooperation plays a key role in support of the national and regional efforts of countries to build and put to good use their scientific capacity. Scientific exchange will reinforce existing collaboration at regional level and promote new partnerships through the development of mutually beneficial research and development programmes.

Once the complexity of science and technology is taken into account in all its dimensions, the advantages of global and regional interaction, networking and coordination is an obvious opportunity. When the challenges of environmental problems are involved, this cooperation in science and technology becomes imperative.

Regional cooperation has to be open and inclusive. It should be encouraged to cooperate with other international and regional research organizations and scientific societies in the region to expand and upgrade capability of scientific and technological collaboration of the Asian countries. I hope that it could be made fully use of existing research and coordination mechanisms to broaden the mutually beneficial cooperation in the region.

Last but not the least, we need to involve the whole of society. Science and technology are enablers. They empower people and open new avenues and opportunities for participation and social inclusion. In this regard, I am very glad that a segment of our Forum is devoted to the Parliamentary dimension of Science and Technology. Parliamentarians as elected representatives of society have a crucial role to play in strengthening the society’s perspectives on science and technology at national and regional level.

The need to reinforce regional cooperation among countries is a subject of strategic importance for UNESCO. While UNESCO has an international mandate and also responds to the requests of individual Member States, we attach great importance to cooperation and integration at the regional level as one of the key means of addressing issues of globalization. Using our network of field offices, we are consulting with a wide
variety of stakeholders as we elaborate regional and sub-regional strategies to foster cooperation and integration at these levels.

It is UNESCO’s belief that effective regional exchange and collaboration in science and technology is a powerful tool in order to: (a) tap the human potential in the Asia region as a whole and take advantage of these resources for the well-being of the people and for the economic development of the region; (b) build capacity and empower people in the region; (c) foster increased bilateral cooperation between countries in the region through greater networking and exchange of resources; (d) address regional problems, such as poverty, climate change, loss of biodiversity, natural disaster and other areas of common interest. In other words, that the development of regional partnership in the field of science and technology will serve common interests among Asian countries and contribute to lasting development in Asia and the world.

In closing, I hope that during the coming days we will have the opportunity to address different methods of strengthening scientific cooperation in the region and look forward to interesting discussions.

UNESCO will pay great attention to the outcomes of this Forum, and is fully committed to working closely with you to achieve our common goals. I wish you every success in your discussions.

Thank you
Science, Parliaments and Scrutiny

Dr Chandrika Nath,
Parliamentary Office of Science and Technology, UK

In this paper I will discuss the importance of providing objective scientific advice to parliamentarians, and the various possible methods available of delivering that advice. My paper is based on my own experiences of providing scientific advice to the UK parliament for the past 8 years as an adviser with the UK Parliamentary Office of Science and Technology (POST). I will also discuss experiences of building scientific capacity within African parliaments, focusing on the Parliament of Uganda.

Parliamentarians need scientific advice for a wide range of reasons. Often it is assumed that the key reason they need this advice is to make decisions on national science policy and funding. However, science underpins all areas of parliamentary activity. For example, MPs need to understand any scientific issue which is of concern to their constituents. In the UK this can range from waste management through to drug pricing or the health effects of mobile phones. Parliamentarians are also required to debate issues of national importance, and to debate legislation which might be underpinned by science – anything from national security to energy policy to regulation of the internet. The graph below shows how the proportion of parliamentary questions on scientific issues increased sixfold from 1988/9 to 1998/9.

Finally they play a key role in holding government to account by scrutiny in parliamentary committees.

In a survey of 50 MPs and Peers from the UK parliament conducted by POST in 2009, over 90% of interviewees said that having an objective, independent source of information on science and technology written specifically for parliamentarians was very important. Moreover, many stressed that advice to parliament should be kept separate from advice to government which parliament is there to scrutinise.
In the UK at least, there is no lack of scientific information. Parliamentarians are inundated with information on from a range of sources including lobby groups and constituents as well as a mass of information available via the Web. But they may not have the time or specialist expertise to separate out good information from bad or to identify when a source is biased or has its own agenda. So a trustworthy source of accessible information on science is invaluable. Such information is often provided by parliamentary staff.

POST’s role in the UK parliament is to provide objective analysis and advice on S&T issues relating to public policy. POST staff have been supporting both Houses for over 20 years. A network of similar offices exists across Western Europe called the European Parliamentary Technology Assessment network (http://www.tekno.dk/EPTA/). POST’s main output is a series of 4 page policy briefings on a range of scientific issues. These briefings are aimed at informing parliamentary debate and are widely used by parliamentarians prior to debating in the House, talking to constituents or to the media. POST also runs a series of well attended seminars and events on scientific issues as well as providing support to parliamentary committees.

Over the past 5 years POST has seen an increase in the number of inquiries about its work from African MPs and staff. African parliaments have to grapple with many scientific issues ranging from exploitation of natural resources to meeting the MDG targets. Yet few have studied science beyond high school; moreover they have fewer support staff than their counterparts in developed countries. Thus the common complaint is that legislation is often simply “rubber stamped” by African parliaments because MPs do not understand it; scientific issues rarely get a fair debate.

For the past 3 years POST has been running a charitable programme focussed on the Parliament of Uganda with support from the Gatsby Charitable Foundation. This programme aims to help the Parliament of Uganda find its own ways to improve scientific support to MPs and thus to improve its scrutiny of government. Initial research by the programme shows a high level of enthusiasm for science and technology – illustrated by developments such as the setting up of a dedicated committee on science and technology – a trend seen in parliaments across Africa. However in spite of this enthusiasm, both MPs and staff have very limited links with the Ugandan scientific community and have limited skills in identifying reliable scientific information on the internet. This prevents them from obtaining timely advice on scientific advice to support parliamentary debate. Our programme has focussed on addressing these gaps.

One of the most popular activities supported by the POST Africa programme has been the establishment of an “MP-scientist pairing scheme”. This is modelled on a scheme operational in the UK parliament and set up by the UK’s Royal Society. It involves linking up pairs of Ugandan scientists with Ugandan MPs. The scientists spend a week shadowing their paired MP in parliament, attending committee meetings and debates with them as well as having many informal discussions about a scientific topic identified in advance of the week. Following this week, the scientist and MP visit the MP’s constituency and the scientist’s laboratory together. The scheme has helped MPs and scientists understand the constraints under which each operates, as well as helping extend parliament’s links with the indigenous scientific community.
In addition to MP-scientist pairing, POST has provided training to parliamentary staff, largely through in country workshops but also through some staff visits to the UK. This training has focussed on helping staff to identify reliable scientific information on the internet and communicate it in an accessible way to Ugandan parliamentarians.

A number of outcomes of POST’s activities in Uganda can already be seen, for example better links between Ugandan scientists and parliament, and joint projects initiated by paired MPs and scientists. However, it is too early to assess the impact of the activities. Moreover there are many donors operating in the parliament of Uganda and it is hard to assess the impact of one donor in isolation.

POST has not yet operated outside Uganda, but a range of other donors such as the Association of European Parliamentarians for Africa (AWEPA), the International Network for the Availability of Scientific Publications (INASP) and UNESCO are also involved in building the capacity of African parliaments to handle scientific and technological issues. In addition, a growing number of national science academies in African countries are working on strengthening links with their parliaments; POST works closely with the Ugandan National Academy of Sciences (UNAS).

Donor activities in this area can be very valuable, especially when they are designed in consultation with country partners (such as the science academies) and based on detailed research into the needs of MPs and staff. For example analysing the scientific content of parliamentary debates, looking at reports on scientific issues produced by parliamentary committees, and looking at briefings prepared by staff for MPs, can reveal a great deal about what the real needs are. It is also very important to minimise duplication of activities between donors, otherwise MPs and staff can find themselves taking more time out of their daily work to attend donor funded activities than is necessary.

In summary, provision of independent scientific advice to parliamentarians is of key importance in developed and developing countries. In most parliaments in developed countries, diverse systems for delivering scientific advice have evolved over the last 20-25 years. In most developing country parliaments, such systems are still weak and many different groups are involved in building capacity in this area. While lessons can be learned by studying processes in developed countries, but each country operates in its own unique context and what works in one country may not work in another. Parliamentarians, the scientific community and donors all have a role to play in developing this crucial area of parliamentary strengthening.

For more information on any of the issues discussed in this paper, please contact Dr Chandrika Nath on nathc@parliament.uk
Dr. Paula Tiikhonen, Hon. Shri S.S. Ramasubha, Dr. Narong Boonyasaguan

Dr. P Benerjee, Director, NISTADS
Can Parliaments be active in the Modernization process?

Doctor of Administrative Sciences Dr. Paula Tiihonen
Committee Counsel to the Committee for the Future, Parliament of Finland

Parliaments have also visionary power

We are used to think that Parliaments all over the world are those old-fashioned institutes which respect history and traditions. Parliament’s task is to decide on laws and the State Budget – and that's it. Parliaments protect Status Quo We also know that Parliament is not a place to rebel or start a revolution. Do Parliaments have anything to do with modernization process?

My short answer is absolutely YES. Politics is all about shaping and making our common Future which cannot be understood without modernization and rethinking. In all politics the future must always be taken with care into consideration. But to be able to do this, you need forums for future-oriented thinking and above all forums to make political, financial and juridical decisions on the future. These forums must be situated as close to centres of power as possible.

In Finland the Eduskunta, – which as the national parliament is certainly one of the centres of power – decided in 1993 to establish a special committee to deliberate problems of our shared future.

The powers of the Eduskunta are as in any other Parliament. They can be divided traditionally into legislative and budgetary but as my example will show, nowadays also into visionary power. The Committee for the Future was created to strengthen the visionary aspect – the modern aspect - of power. And it was a real rethinking body from very beginning. Future-oriented committee was tentatively named the Committee of the Future - very neutral name - but I would say it got off to a very good innovative start when in it's very first meeting the 17 members (all parliamentarians, representing the full spectrum of political parties) decided to change the name to the Committee FOR the Future. The change of preposition demonstrated that they wanted their committee to be active rather than passive; to be for the future not against it, to take an innovative attitude to science and technology and not resist it merely because it is new, and so on.

Parliament wanted to be a part of modernization process at the beginning of the 1990', in the situation where Finland was in deep depression. The committee wanted to be a part of Finland's victory over those hard times.

Setting agenda

It is an adage of political life at any level that the first step to power is to take the initiative and put yourself in a position where you can set the agenda. In the Eduskunta, the Committee for the Future has taken this adage seriously from the very beginning. The only rule in setting an agenda has been that it has to be something that is new and important to people. Of course the idea is to tackle only big issues, but we have to be humble and admit that we see small things better. Some of them can turn out to be big matters.
Having a mission and working hard during these years, the committee has taken its place in the Finnish parliamentary system as an innovative political body. Very often it is called a think-tank of Parliament. Anyway, over the years it has created a new forum that works at the core of the parliamentary system and – even more important – has demonstrated that parliamentary measures can still be used to take the initiative within democracy.

One principal statement of the committee is: *It is the duty of parliament to observe the changing world, analyse it, and take a view in good time on how Finnish society and its political actors should respond to the challenges of the future. Democracy cannot be realised simply by accepting changes that have already taken place* (Committee for the Future, 1998).

Politics in this context is about values, attitudes, atmosphere and opinion building, and, most important, opinion leading. Nowadays politics too often is against change and against new things. It is said, and even believed, that voters do not want new things. But in this democratic system of ours the point is just the opposite, which is why politics is needed, to support new ideas, and, among them, new innovations, both social and technical ones. Even when it is a question of really fundamental institutions, which you certainly should preserve and protect, there is need to discuss connections to other institutions, which are changing for sure.

Even with the oldest institution of mankind, the family, you have to be ready to understand new ways of thinking and new ways of doing, both now and in the future. The environment in which people are living as family members is always on the move.

Following and understanding the changing world is not enough. In order to be committed and effective politicians have to be active. They have to be creative actors and take a positive initiative. The role of Parliaments is the same all over the world: to reactively handle proposals for legislation and annual budgets given by Governments. Limits for parliamentarians even to talk about something the government has not prepared and proposed are difficult in practice. Can Parliament be a forerunner and an active player for a new society? The Committee for the Future, which is a unique invention of Finnish democracy and its core, the country’s Parliament, has proven that.

**A long way**

In 1906 Finland was the first country in the world to give full voting and candidature rights to women, which can be an explanation for why, after 100 years of this kind of great social innovation, the same Finnish Parliament was the first in the world to decide that our common future is so important that politicians also have to take real responsibility for it. The Committee for the Future was established at the beginning of the 1990s and functioned on a temporary basis from 1993 until 2000. Then, on 17 December 1999, in conjunction with its adoption of new Rules of Procedure compatible with the new constitution, Parliament decided to grant the Committee for the Future permanent status.

Giving a standing committee within the Finnish parliamentary system a new, future-oriented role of this kind was not at all easy, for many reasons. What has been remarkable in light of this is that the initiative came from the legislators themselves.
As early as 1986, 133 of Parliament’s 200 members presented a citizen’s initiative to the President of the Republic, the Speaker’s Council of Parliament and the Government, proposing the creation of a futures research unit within the legislature. The proposal, which did not lead to measures being taken, was dealt with then (1986) as a written parliamentary question. Again in the early 1990s, a number of members realised that Parliament needed a new type of forum for discussion, a new means of guidance, a mechanism which would not be tied to the Government’s detailed, separately submitted, and, in most cases, narrowly focused bills. This insight was prompted by Parliament’s recognition that in a smoothly functioning parliamentary system opportunities to amend Government bills or budget proposals are naturally rather limited. This configuration has become more pronounced since the end of the 1970s because Finland has had a succession of broadly based Governments, each serving for a full parliamentary term. In addition, EU membership has created a new operating environment for legislative work and the use of State funds. The 1992 legislative proposal, which, like the earlier one, had the support of 166 members, was likewise rejected. Nevertheless, a process of maturation towards acceptance of a new kind of task had gotten under way, because the Constitutional Law Committee itself expressed support for the matter in its own submission. It wrote:

“The Committee requires, however, that already in the course of the current parliamentary term the Government provides the Eduskunta with a report containing perceptions, which have been shaped by means of futures research, of essential features and alternatives in future development as well as outlining the goals set by the Government, i.e. a general outline of the kind of model of society the Government aspires to achieve through its own actions during its term of office. Drafting a report of this nature will call for interdisciplinary material of a kind not necessarily available to the Government. Therefore, it would be advisable to organise within the Government administration a system of information procurement that would make use of, in addition to traditional economic forecasts, also the means that futures research offers.”

In the same year (1992) Parliament adopted a resolution requesting the Government to provide it with a report concerning national long-term development trends and related options. The legislature appointed a special Committee for the Future for the purpose of evaluating the Government’s views and responding to them.

Resistance continued. The complete reform of the Constitution in 2000 served as a good example of the difficulty involved in changing the traditional thinking patterns of politicians, and especially civil servants, in bringing about an understanding that politicians bear more responsibility for our shared future. None of the preparatory groups even noted the Committee for the Future, which, by that time, had been in existence for nearly ten years. Only after the Constitutional Law came up for parliamentary reading did the Members of Parliament in the Committee for the Future propose granting permanent status to the committee. Parliament’s Constitutional Law Committee opposed the proposal, which was defeated in voting. The decision was then transferred to Session Hall where the issue was decided in favour of the Committee for the Future. It may be presumed that this is the first time that Finnish legislation has been passed in a manner
that reverses like this the position of the Constitutional Law Committee. This unusual event results from the fact that Finland does not have a Constitutional Law Court; instead the Constitutional Law Committee serves as the supreme supervisory body for the constitution. The Members of Parliament tabled a motion, took control and got their way.

The reasons for resistance are many, but the most important was power. The final positive decision is after all that matter. "The Future is permanent" as members of the Committee said.

**Tasks**

The main task of the Committee is: Dialogues with the Prime Minister's Office and Government on future-related issues. Nowadays the Committee has the same status as the other standing committees. Its current tasks are defined to be I) to prepare material to be submitted to the Finnish parliament, such as government reports on the future, II) to make submissions on future-related long-term issues to other standing committees, III) to debate issues relating to future development factors and development models, IV) to undertake analyses pertaining to future-related research and IT methodology, and V) to function as a parliamentary body for assessing technological development and its consequences for society.

All members of the Committee are MPs, and like most of the other standing committees it has 17 members. It neither concentrates on preparing legislation nor reviewing the government's annual budget proposal, but in other respects it resembles the other committees. What makes it different is the nature of its functions and its new fields of tasks. Its task is to conduct an active and initiative-generating dialogue with the government on major future problems and the means of solving them. Each of the standing committees has its corresponding ministry, and in the case of the Committee for the Future this is the Prime Minister’s Office. Since the problems of the future, and, above all, its opportunities, cannot be studied through traditional parliamentary procedures and work methods alone, the committee has been given the specific task of following and using the results of research. Indeed, the committee can be said to be making policy on the future, because its goal is not research but rather policy.

Five Government Reports, with five Parliament responses, have been handled in this dialogue on the future. The first, presented by the government in 1993, dealt with Finland and its relationship to changes in its operating environment. The next government submitted two reports: one in 1996 on the future of Finland and Europe and another in 1997 on Finland's economy, the Finnish employment situation, science and technology in Finland, the Finnish environment, and the country's general wellbeing. In 2001 the Government formed after the 1999 elections submitted a report on the future with regard to regional development. The outlook for demographic development, production and employment over the next fifteen years were the particular foci of examination in this report. The last Governmental Future Report at the end of 2004 was named Finland for people of all ages, dealing with demographic trends, population policy, and preparation for changes in the age structure. Parliament gave its answer on 1st June 2005. The Committee has drafted a relatively lengthy (over 100 pages) report of its own in response to each of the five Government Reports. Each of the committee’s
response documents, with minor additions, was adopted by Parliament after a debate at a plenary session.

The committee has made active use of its power of initiative in defining its own work. After every election the agenda of each new committee takes shape in the minds of the 17 parliamentarians elected onto it. The topics discussed by the committee have ranged from the global to the local, from values to the practical efficiency of the machinery of State, from left to right, from history to the future, from structural long-term economic problems to the everyday difficulties that families have in arranging child care, from statistics to weak signals. The only rule in setting an agenda has been that it has to be something that is new and important to people. Topics in the information society development that the Committee for the Future has highlighted include the future of work in Finland, the future of the Finnish knowledge society and regional innovation systems.

Through its deliberation of the five Government Reports on the future and its own reports in response to them, the Committee has significantly deepened and expanded the Government’s view of the future. It has also initiated technology assessment in Parliament. Both of these new parliamentary tasks have meant a lot of work on the level of public opinion - the level of values and attitudes - such as organising seminars, regional and Internet conferences, having committee sessions among people, and so on. For example, the committee has emphasised that globalisation and modern technology are not isolated phenomena in our society. They are not simply problems faced by businesspeople or engineers; they are factors that permeate the whole of society and affect us all.

A success?

I have been working in the Committee for the Future from the very beginning, so perhaps it is not fair to say anything about success. One thing is certain however: the committee has taken its place in the Finnish parliamentary system as an innovative political body. It has created a new forum that works at the inner circles of the parliamentary system and – still more important – it has demonstrated that parliamentary measures can still be used to take the initiative within democracy.

Second, it is an excellent vantage point. When the main task is dialogue with the Prime Minister's Office and Government on future-related issues, it has been said of the Committee for the Future that it is a good forum where parliamentarians can broaden their views beyond everyday politics and their own country’s problems. The committee’s work has become quite international in character. It has been a model for other parliaments and during last and this year also for Unesco/Iseesco when they have organized future forums and technology development platforms.

Quite a large proportion of the Ministers in the present cabinet are former members of the committee. They include the Prime Minister and the Ministers of Finance, Labour and the Environment. Two party leaders and a leader of the second biggest party group in Parliament have been members of this committee during last periods. The chair of the committee during last period was chosen as the leader of the biggest opposition party in the summer of 2004, one year after the elections. He enjoyed his work on the Committee for the Future so much that he has continued to chair it. Now
he is Minister of Finance and quite sure coming next Prime Minister after elections in April 2011.

The latest own issue is democracy – a lot of modern thinking and doing is needed

Most of work in the Committee is based on initiatives of the Committee members. At the end of this article I will open one issue, which is actually the latest question to which the Committee has turned its attention during many periods. It is the future of democracy.

In summer 2006 the committee published the book Democracy and Futures (2006, eds. Mika Mannermaa, Jim Dator and Paula Tiihonen), in which an international network of futures-oriented writers outlined their vision of the development of democracy. The idea was to allow professional futures-thinkers to approach the theme of democracy and futures from different cultural, scientific, technological, geographical and other perspectives. My own contribution was titled DEMOCRACY IS INSTITUTIONAL GARDENING: a hundred years is a short time. Here I shall take a look at the most important message in that article. It concerns something that I believe is a question of destiny for European democracy. Put briefly, it is the need for sharing.

The challenge facing the future of European democracy is intertwined with its demographic development and how its economic prosperity develops relative to the regions surrounding Europe. The scenario for the development of Europe’s demographic structure is clear. If the present demographic forecasts prove accurate and the European Union does not open its borders to migration, Europe will lose its power of renewal. Investment will not flow into Europe, which will lack consumer demand and growth dynamism. It will also become more difficult to maintain infrastructure. The problem of a downward spiralling in standards of living can be solved in three ways: 1) by increasing the birth rate and restoring natural reproduction to its former level, 2) by opening borders to immigrants or 3) by doing both.

Another major challenge facing the future of European democracy relates to the development of the global environment and a third to the stark differences between the cultures of Europe and those of the surrounding countries. These questions are intertwined. Already now, drought and shortage of water are plaguing especially North Africa. Global warming is forecast to exacerbate the situation. The situation is not as bad on the northern side of the Mediterranean. In addition to this, the Mediterranean is a border between Christianity and Islam, between democratic and non-democratic political systems as well as between regions of slow and fast population growth. European democracy will be put to the test when drought and the shortage of water worsen and the countries of North Africa are unable to find a solution to the spiral of poverty. How will Europe respond to the problem of poverty and prosperity and, in the worst case, the human catastrophe to which it will give rise? The present youth unemployment in North Africa is a good example of the slowly developing social threat of poverty. Most of the world’s unemployed people are growing up to the south of the Mediterranean. There are tens of millions of them. Looking at the matter from the angle of European democracy, we have to ask where these young people will direct their energy.
From the perspective of Europe’s economy and democracy and also ethically, it would be desirable for the Mediterranean to unite rather than divide. Europe needs young workers and innovators. Europe should open her borders. The more robustly this is done, the more strongly Europe will change. It will mean that the Christianity-based foundation of European democracy will change and nationality will lose its relevance as the foundation of national democracy. Europe’s present political decision makers will have to ponder the most profound foundations of democracy and adopt a position on nationality and what liberty, fraternity and solidarity mean in relation to new immigrants. Is religion part of European existence? Does democracy mean equal rights for all irrespective of religion and birth or only for native citizens? What does nationality mean? If new population groups come to Europe, their religion will be different. They will speak different languages and have a different cultural identity. Will immigrants be given the same political, economic and social rights as the indigenous population? It is obvious that the effects of both alternatives will be dramatic. Giving immigrants full civil rights and applying democratic principles to immigrants or discrimination against them, i.e. denying them democratic rights, will change political configurations in European countries.

Why is it so difficult to share? Why is it that for instance even native third-generation immigrants can not be citizens in so many European country? For instance German Turks – those born, raised and educated in the German society – are denied full rights of citizenship. Real democracy runs deep in social and cultural structures, ways of living and mindsets. If 80 million Germans adopt a cautious attitude in relation to their own heritage, what can we expect of smaller and more homogeneous nations?

Strong signals of a very problematic future in Europe can be seen in the latest alleged terrorist plot in London on 7.8.2006 (possibly involving the destruction of 10 transatlantic planes). People all over Europe listened to the news and thought: Can it be true that dozens of British-born people could plan that kind of mass murder in their own country – what does citizenship mean?

I want to emphasise that I am not talking about foreigners only as workers, scientists or artists. I am talking about foreigners among us at every level of life and I am talking about democracy in people’s normal life - the way of thinking, doing, being, living and loving.

Many experts say that the US and Europe are so different. The US gives work, but not social security and social welfare (benefits) to foreigners. Europe gives social security but not work. If true, what does it mean and which one is better?

I think the problem runs deep into the nature of democracy. What is ultimately involved in democracy is people’s opportunity to influence their own lives. They must be able not only to influence the formation of their own country’s government, but also to participate directly in some of the regional and global processes that affect their lives. All of this presupposes, in addition to the basic institutions of democracy, also personal autonomy. As John Stuart Mill puts it in Utilitarianism: “If a person possesses any tolerable amount of common sense and experience, his own mode of laying out his existence is the best, not because it is the best in itself, but because it is his own mode.”
A proposal to link Science and Technology to Politics and Government

Dr. Avudh Ploysongsang
Advisor to the Standing Committee on Science and Technology,
The Parliament, Thailand

The advancement in science and technology, created mostly in various development countries, has tremendously benefited mankind, but has also brought about many serious problems. One of the most problems is the uneven distribution of the benefits itself. The one who owns the technology gets more benefit in terms of profit. Others pay for the benefit, whatever it is. The situation drives developing countries to put efforts in the development of science and technology in the hope of being able to compete or at least having their own technology. Unfortunately, they are not easily successful for various reasons.

Also, there is other problem such as in the case of DDT which is a clear example of an unexpected long lasting disastrous side-effect of a seemingly beneficial technology. Recently, the BP disaster is another example of the technology gone-wrong. Many times, the problems are not clear-cut or easily fixed. They can be very complicated and can involve many aspects of social issues, let alone human nature such as greed or abusive behaviors.

In any case, scientists and technologists, by their actions or non-actions, can be identified as the direct or indirect causes of those problems. Therefore, it is fitting that scientists and technologists have to provide the solutions to those problems. That is, the people in the science and technology communities have to come up with appropriate actions to alleviate those problems and prevent them from reoccurring. The question is "HOW?"

In many cases, scientists and engineers have ideas for coming up with scientific or technological solution. They also have the mandate. However, many problems which are complicated cannot be solved by then alone. The whole society has to be involved. The key part of the society that plays very big role in the solutions is the Government which itself is a part of the political system.

The question becomes “How do we get the Government to want to solve those problems?” In many countries, the government is quite busy with politics and hundreds of economic and social issues. They hardly understand science and technology; and worse than that, they do not understand the importance of science and technology. In a government, such as one in Thailand, scientific or technological issues are handled by the Ministry of Science and Technology. Unfortunately, those issues may lie across many ministries, for instances, Ministry of Energy, and Ministry of Environment and Natural Resources, and /or Ministry of Agriculture, and / or Ministry of Industry, and / or Ministry of commerce, and / or Ministry of Education and so on. Just some simple politics can destroy the whole structure of any solution that may exist. The situation requires a Government leader who can understand science and technology and can direct
the correct course of actions. This is a difficult situation since political leader are usually not scientists nor vice versa.

To alleviate this situation, scientists or technologists can try to become political leaders and hope that one of them can become the leader of the Government. However, this is very difficult since scientists or technologists can hardly become good or capable politicians.

One of the possible solutions then is for the country to have a Chief Technical Office (CTO) in the same manner as having an Economics Czar who is in charge of economics issues which may lie across a few ministries in country. A CTO should be at the senior minister or the deputy prime minister level. He is selected and appointed from the Science and Technology Community. He should have vast experience in science and technology including skill in any related field and is capable of bridging the gap between science and politics. Having a CTO in the government signifies that the country recognizes the importance of science and technology. The CTO will comprehensively oversee the science and technology issues for the country. He will assist the leader of the Government in directing the development and advancement of science and technology for the benefit of the country. Moreover, he will help the leader of the government by being responsible for supervising ministries on the issues and activities that may be related to science and technology. They are the Ministry of Energy, the Ministry of Environment and Natural Resources, the Ministry of Agriculture, the Ministry of Industry, the Ministry of Defense and the Ministry of Education.

Together with having a CTO in the Government, the country should employ the collective wisdom of the science and technology community. To accomplish this, a formal and official forum of scientists and technologists can be formed within the government or the political system. The forum may be called a congress of Science and Technology. Members of this Congress are duly elected from various parts of science and technology communities. The appropriate number may be between 100 and 200. One of its main functions is to support the CTO, who is a part of the Government and the Chairman of this Congress, in advancing the science and technology for the needs of the country, such as improving the competitive edge and the well being of the people. During the annual national budgeting process, this congress can perform the screening function for the government. Together with the CTO, they can effectively alleviate the problem of misplacing or random cutting or reduction of the proposed budget by endorsing and defending the reasonable budget proposals. They can help the parliament to be better-informed and more effective in their consideration and judgment of the budget relating to science and technology. They can also reform functions such as advising and providing knowledge and understanding of complicated science and technology issues for the members of the parliament. Moreover, they can help draft the laws or regulations in science and technology.

The CTO and the congress of Science & Technology will work together to represent the science and technology stance or position of the country in issues that are the concerns at the international level, for examples, global warming and food security. They can cooperate the collaborate with other countries in the region or any country in the world for the purpose of resolving problems relating to science and technology, especially the elimination of poverty or unfairness.
A well designed and carefully implemented process of public exposure of the CTO and the Congress of Science & Technology will gain the acceptance of the general public and increase the awareness of science and technology to the population which, in turn, will strengthen the development of human resources in science and technology.
Dr. Nilawan Petcharaburanin
Dr. Nilawan Petcharakuranin
Senator and Vice Chairman of the Standing Committee on Science, Technology
Communication and Telecommunications, Thailand

Closing Remark

Good Evening Ladies and Gentleman, it is an honor to be in part of the conclave under the title “Regional cooperation in Science & Technology: Opportunities and Challenges in the context of Globalization”. This is quite an auspicious event. We have gathered people from all over the world, who are not only knowledgeable in science and technology but also considerate to the world we are living. We have addressed the essential global issues of climate change, science technology and innovation policy, health service, science and economics development, impacts of science and technology on society, innovation management and technology transfer, and information and communication technology, Yesterday we had a very constructive discussion regarding regional cooperation in science and technology. This conclave has led us a promising opportunity in utilizing science and technology at its best. We have successfully pioneered in unifying the ultimate solutions for making our world a better place. Because this planet belongs to all of us, we need to bring the world together as one. Thank you everyone for your great dedication to make this happen.
Annexures
Technical Program of the Conclave


Program is comprised of invited lectures, Contributed papers and extensive discussion.

First Day: 26th November 2010

8:30 AM to 9:30 AM : Registration Time

9:30 AM to 11.00 AM : Opening session

Inaugural Address : His Excellency, Dr. B P Singh
Hon. Governor of Sikkim.

Opening Addresses : Chaired by Dr. Abid Hussain
Formerly Ambassador of India in USA.
Dr. Lidia Brito, Director, Science Policy Division,
UNESCO, Paris
ISESCO Representative.
Dr. G. Thyagarajan, Formerly Director, CSIR
Institutes, Govt. of India. Presently, President, Madras
Science Academy, Chennai
Prof. J N Nanda, Formerly Director, Defence Institute
of Advance Technology (DRDO)
Dr A R Kidwai, Formerly Governor of several Indian
States, Ex Member Parliament & Presently Chairman,
Zaheer Science Foundation, New Delhi

Vote of Thanks : Dr. Mohsin U Khan
Secretary, Zaheer Science Foundation, New Delhi

11:00 AM to 11:15 AM : Coffee Break

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11:15 AM to 1:30 PM : Session 1

11:15 AM to 11.45 AM : Keynote Address

Chair : Dr. G. Thyagarajan, Formerly Director, CSIR Institutes, Government of India Presently, President, Madras Science Foundation, Chennai

Rapporteur : Dr. Sunita Garg

Speaker : Dr. V Prakash, Director, Central Food Technology Research Institute (CFTRI), Mysore.

Title : If climate change and food matters to us, we shall matter more to it.

11.45 PM to 1.30 PM : Climate Change & Environmental Issues

Chair : Dr. Shahid Siddiqui, Pritzker School of Medicine, University of Chicago, Illinois, USA

1. Speaker : Dr. S. Rajamani, Chairman, International Union of Environmental Commission, Chennai, Tamil Nadu

Title : Recent Technological Developments in Cleaner Production and green development for control of green hydro gas emission and climate change.

2. Speaker : Dr. Syed E Hasan
Director, Center for Applied Environmental Research and Professor of Geophysics, Department of Geophysics, University of Missouri-Kansas City, USA.

Title : Proper waste management: An economic & Environmental Imperative.

3. Speaker : Dr. M U Beg
Senior Scientist, Environmental Sciences Department, Kuwait Institute for Scientific Research, Safat, Kuwait.

Title : Persistent Toxic Chemicals: Problems & Prospects in Developing Countries.
4. Speaker : Professor M. P. Srivastava  
Professor, Department of Physics & Astro-physics, Delhi University, Delhi  
Title : Sustainable development and carbon dioxide decomposition by plasma route to combat climate change.

1.30 PM to 2.30 PM : Lunch Break

2.30 PM to 4.30 PM : Session 2  
Science Technology and Innovation Policy

Chair : Dr. S Tanveer Kausar Naim  
Formerly Chair, Pakistan Council of Science & Technology  
Presently Consultant, COMSTECH, Islamabad, Pakistan

Rapporteur : Dr. A K Mathur

1. Speaker : Dr. Pichet Durong Kaveroj  
Secretary General, Thailand National Science Technology & Innovation Policy, Thailand  
Title : Boosting National Competitiveness through science, technology and innovation.

2. Speaker : Dr Kitipong Promwong  
Director of Policy and Management Department, The National Science Technology & Innovation Policy, Thailand.  
Title : Science & Technology Manpower capability building.

3. Speaker : Dr. Taeyoung Shin  
Senior Fellow, Science & Technology Policy Institute, Seoul, S. Korea  
Title : S & T and Economic Development: Government Policy, for S&T development in Korea.

4. Speaker : Dr. Raine Hermans
Adjunct Professor, Director, Impact Analysis, TEKES, Helsinki, Finland.

Title: *Finnish Mosaic of Regional System: Assessment of Thematic Regional Innovation based related variety*

5. Speaker: Dr. Nadia Asheulova, Russian Academy of Science, Moscow
Title: *International mobility as a mechanism for reproducing Scientific Elite*

6. Speaker: Dr. Darryl Macer, Regional Advisor on social and human science in Asia & Pacific, UNESCO, Bangkok
Title: *Building infrastructures to better ensure ethical science policy*

**4.30 PM to 4.45 PM**: Coffee Break

**4.45 PM to 6.15 PM**: Session 3
Health Services

Chair: Dr S.H.A. Abidi, Formerly Vice Chancellor and Director, Central Institute of Fisheries Education, Mumbai
Rapporteur: Dr. Syed E Hasan

1. Speaker: Dr Sunil K. Sharma, Professor, Department of Chemistry, Delhi University, Delhi
Title: *Bio Catalytic Synthesis of Polymeric Materials for Drugs and Gene Delivery Applications.*

2. Speaker: Dr Sadhana Srivastava, Intellectual Property Rights unit, Indian Council of Medical Research, Department of Health Research, New Delhi
Title: *Promoting access to medicine through global cooperation: A Strategy through north south cooperation*
3. Speaker : Dr Rita Singh, Associate Professor
Department of Zoology, Delhi University, Delhi

Title : Reproductive Health Concerns: The impact of Environmental Toxicants on Reproductive health of women/men.

4. Speaker : Dr Shahid Siddiqui,
Section of Pulmonary & Critical Care Medicine,
Pritzker School of Medicine, University of Chicago, USA

Title : Micro Solution of Complex Human Disaster: Role of Micro-RNAs in Health & Pathogenesis.

5. Speaker : Dr. Lalit Kant
Head, Division of Epidemiology & Communicable Diseases
Indian Council of Medical Research, Delhi

Title : Draft National Health Research Policy

7:30 PM : Official Dinner

Second Day 27TH November, 2010

9:30 to 11.30 : Session 1

9.30 to 10.00 : Keynote Address

Chair : Dr Torsti Loikannen, Senior Manager, VTT Chemical Technology, Innovation Studies, Helsinki, Finland

Rapporteur : Dr. Tabassum Jamal

1. Speaker : Dr S Tanveer Kausar Naim

Title : Migration of the highly skilled from Pakistan and Bangladesh and its impact on Technological and Economic Development.

10.00 AM to 11.30 AM Science Technology & Economics Development

Chair : Dr. Lidia Brito, Director, Science Policy Division, UNESCO, Paris
1. Speaker: Dr. Rustrem Nureev
   Professor, State University Higher School of Economics Moscow, Chief of the Department of Economic Analysis of Markets and Organizations, Moscow, Russia
   Title: Institute Perspective of Innovative, Technological and Structural dynamics.

2. Speaker: Professor Tateo Fujimoto
   Professor, Department of Economics, Kanon University, Japan
   Title: Lessons from the age of post war economic miracle in Japan

3. Speaker: Dr. Svetlana Kirdina,
   Institute of Economics
   Russian Academy of Sciences, Moscow, Russia
   Title: Prospect of Liberalization of Science & Technology Policy.

4. Speaker: Professor Arif A Waqif
   Professor & Founder Dean, (Rtd.), School of Management, University of Hyderabad. Chair Professor, Chairman (Economics) and Dean (Research) ASCI, Hyderabad
   Title: Social & Political Economy of Modern and Traditional Technologies: Some Conceptive Perspective

5. Speaker: Dr Ramesh M Singh, Centre for Energy & Environment, Nepal
   Title: Capacity building of Tumba College of Technology in Bwanda South-South Cooperation on AE development

6. Speaker: Dr L Prasad
   Indian Institute of Management, Bangalore
Title : Multinational R&D Consortia: An InterOrganizational Perspective on Enhancing RegionalCo-operation in Science and Technology.

11:30 AM to 11:45 AM : Coffee Break

11:45 AM to 1:30 AM : Session 2

11:45 AM to 12:15 PM : Keynotes Address

Chair : Dr. M.U.Beg
Senior Scientist, Environmental Sciences Department, Kuwait Institute for Scientific Research, Safat, Kuwait

Rapporteur : Dr. Aqueil Ahmed

Speaker : Dr. Lalji Singh
Formerly Director, Centre for Cellular & Molecular Biology, Hyderabad

Title : Genetic diversity in Indian population and its health implications

12:15 PM to 1:30 PM : Science & Technology and its impact on society.

Chair : Dr. Syed E. Hasan
Director, Center for Applied Environmental Research and Professor of Geophysics, Department of Geophysics, University of Missouri-Kansas City, USA.

1. Speaker : Dr. Jay Weinstein
Professor of Sociology, Eastern Michigan University, USA

Title : Back-loading Na-tech into Technological Innovation and application: An urgent call for Globalization.

2. Speaker : Dr. Sunita Garg,
Scientist and Head, Wealth of India
National Institute of Science Communication and Information Resources (CSIR), New Delhi

Title : NISCAIR- The CSIR’s Scientific Information Resources for Science & Society.
3. Speaker : Dr Jyoti S. A. Bhat
Scientist
Ministry of Science and Technology, Govt. of India
Title : Importance of ambidexterity in Science & Technology Policy.

4. Speaker : Dr Marja Hayrinen Alestalo
Professor
Helsinki Institute of Science and Technology Studies, Helsinki
Title : Response of Europe and Asia to the new Global order.

1.30 PM to 2.30 PM : Lunch Break
2.30 PM to 4.30 : Session 3
2.30 PM to 3.00 PM : Keynote Address
Chair : Prof. M. Kamaluddin
Professor & Director, Institute of Appropriate Technology, Bangladesh, University of Dhaka,
Bangladesh
Rapporteur : Dr. A K Mathur
Speaker : Dr Aqueil Ahmed, Core faculty, School of Management, Walden University, North Carolina, USA
Title : Science & Technology and Industrial Development in the People’s Republic of China

3.00 PM to 4.30 PM : Innovation Management & Technology Transfer
Chair : Datuk Dr Mohinder Singh
President, Malaysian Scientific Association
Kuala Lumpur, Malaysia
1. Speaker : Professor & Dr M. Kamaluddin,
Professor & Director, Institute of Appropriate Technology, Bangladesh, University of Dhaka, Bangladesh
Title : A Mode for transforming the research outcome of science and technology for commercial application.

2. Speaker : Dr Annaflavia Bianchi
Faber Industries e futuro, Italy

Title : Innovation Policy and Technology foresight at regional level. The Emilia-Romagria Region experience in Italy

3. Speaker : Dr Jaime Jimenez
Gregory, Sandstorm, Mexico

Title : Going from local to Global: Solving local problems, Inserting into global science.

4. Speaker : Dr. Khaleel Malik
Manchester Institute of Innovation Research (MIoIR), Manchester Business School, The University of Manchester U.K.

Title : Challenges & Opportunities for renewable technologies in the Arabian Gulf.

5. Speaker : Dr. Subhan Khan
Scientist, National Institute of Science Technology and Development Studies (NISTADS), New Delhi

Title : Geospatial Science and Technology Policy of India in Global Context

4:30 PM to 4:45 : Coffee Break

4.45 to 5.15 PM : Keynote Address

Chair : Dr. Aqueil Ahmad, Core Faculty, School of Management
Walden University, North Carolina, USA

1. Speaker : Dr Stefan Kuhlman
Professor, Twente University, Netherlands

Title : Models for Innovation Policy in late industrialization Endogenous vs Exogenous.
7:30 PM : Official Dinner

Third Day: 28th November 2010

9.30 AM to 11.30 PM : Session 1
Information & Communication Technology (ICT)

Chair : Dr Diana Malpede: UNESCO, Paris

Rapporteur : Dr. Subhan Khan

1. Speaker : Dr Daniel Nepelski, EC JRC IPTS, Seville, Spain
Title : "Internationalisation of innovation. The concept and evidence."

2. Speaker : Professor Zahid H. Khan, Director
FTK Centre for
Information Technology, Jamia Millia Islamia
Jamia Nagar, New Delhi
Title : ICT and Changing face of Higher Education.

3. Speaker : Dr Bahawodin Baha, School of Computing Engineering Mathematics,
University of Brighten, UK
Title : Information and Communication Technology (ICT) for Education in Afghanistan

4. Speaker : Dr Torsti Loikannen, Senior Manager, VTT Chemical Technology, Innovation Studies, Helsinki, Finland
Title : Paving way for global knowledge society towards integration of innovation and development strategy.

5. Speaker : Dr. Atsushi Sunami, Associate Professor National Graduate Institute for Policy Studies, Tokyo, Japan
Title : Japan’s New Growth Strategy and its green innovation policy
11.30 PM to 11.45 : Coffee Break

11.45 AM to 1.15 PM : Session 2

11.45 AM to 12.15 PM : Keynote Address

Chair : Dr. J. Perera, Sri Lanka

Rapporteur : Dr. Sunita Garg

Speaker : Dr. R. B. Singh,
Formerly Director IARI, New Delhi
Formerly Chairman ASRB, ICAR, New Delhi
Formerly, Member Farmer’s Commission, Govt. of India

Title : Transforming Agricultural Research for Development

12.15 PM to 1.30 PM : Panel Discussion on Regional Cooperation in Science & Technology: How to go about it?

Anchor : Datuk Dr Mohinder Singh (Malaysia)

Co-Anchor : Dr Mohsin U Khan (India)

Rapporteur : Dr. M U Beg

Panelists : Dr A Parasuramen (UNESCO, Delhi Office)
ISESCO Representative
Dr J Perera (Sri Lanka)
Dr. Ganesh Shah (Nepal)
Dr. Se-In PARK (South Korea)
Dr. A B Mandal (India)
Dr G Thyagarajan (India)

1.30 PM to 2.30 PM : Lunch Break

2.30 PM to 6.00 PM : Free time for one to one interaction on regional cooperation in Science & Technology and opportunity to work out research among the south Asian and Southeast Asian, European countries as well as USA
Fourth Day: 29th November, 2010
Inter Parliamentary Forum of Science and Technology and Innovation
South Asia and Southeast Asia Region

9.30 AM to 1.30 PM : Parliamentarian Session

9.30 AM to 10.00 AM : Opening Ceremony

Chair : Professor Saifuddin Soz
Member Parliament (Rajya Sabha)
Government of India

Welcome and opening remark

: H. E. Dr BP Singh
Hon. Governor of Sikkim
Raj Bhavan
Sikkim

: Dr. Lidia Brito
Director, Science Policy Division
UNESCO, Paris

: Representative of ISESCO

10.00 AM to 11.00 AM : Session 1
Science Technology and Innovation Governance in
South Asia and Southeast Asia

Keynotes speech

: Shri P. C. Chacko
Member, Parliamentary Standing Committee on
Science and Technology, Govt. of India

Chair

Rapporteur : Prof. M. Kamaluddin

Speaker : Dr. Ninlawan Petcharapuranin, Senator and Vice Chairman of the Standing Committee on Science, Technology, Communications and Telecommunications, Thailand

Title :
Role of Parliamentarians in the development of Science and Technology in Thailand

: Mr. Ganesh Shah
Formerly Minister, Govt. of Nepal

Mr. Avudh Ploysongsang, Adviser to the Standing Committee on Science and Technology, House of Representatives, Thailand

11.00 AM to 11.15 AM : Coffee Break

11.15 AM to 12.15 PM : Session 1 (in continuation)

Participation in discussion by Members of the Standing Committee of different countries including India

Mr Narong Boonyasaguan, Advisor to the Standing Committee on Science and Technology, House of Representatives, Thailand

Shri S. S. Ramasubbu  
Member Parliamentary Standing Committee on Science and Technology, Govt. of India

Prof. Saifuddin Soz  
Member, Rajya Sabha, Govt. of India

Shri Sita Ram Yechury  
Member, Rajya Sabha, Govt. of India

12.15 PM to 1.15 PM : Session 2

Building Bridges through dialogue between Parliamentarians, Scientists, Media and Society

12:15 PM to 1.15 PM : Keynote speeches

Chair : Dr. Svetlana Kirdinia,  
Institute of Economics  
Russian Academy of Sciences, Moscow, Russia

Rapporteur : Dr. J. Perera
Speaker : Dr. P Banerjee  
Director, NISTADS, New Delhi 

Title : Science Technology and Innovation Policy focusing on regional cooperation 

Speaker : D. Malpede, Division of Science Policy and Sustainable Development Division, UNESCO 

Title : Science and Technology within Parliament: UNESCO’s Interparliamentary Forums in initiative 

1.15 PM to 2.15 PM : Presentations 

Speaker : Dr. (Ms.) Chandrika Nath  
Parliamentary Office of Science and Technology, UK 

Title : Role of parliamentarian in the development of Science and technology in Africa 

Speaker : Dr. N. P. Singh  
Adviser, Ministry of New and Renewable Energy Government of India, New Delhi 

Title : "Renewable Energy Developments in India”. The presentation will include recent developments, technology demonstration, manufacturing infrastructure, programs/schemes in various States and policies. 

2.15 PM to 2.30 PM : Closing Remarks 

Dr. Ninlawan Petcharapuranin, Senator and Vice Chairman of the Standing Committee on Science, Technology, Communications and Telecommunications, Thailand 

2.30 PM : Lunch
STEERING COMMITTEE

His Excellency, Dr. A R Kidwai, Formerly Governor of Haryana

Chairman

Dr B P Singh, Governor of Sikkim

Member

Dr Mustafa El-Tayeb, Formerly Director, Science Policy Division, UNESCO, Paris

Member

Dr Abid Hussain, Formerly Ambassador of India in USA

Member

Dr P Banerjee,
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