



## **Background Paper of the Task Force on Science, Technology and Innovation**

April 18, 2003

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### **Note to the reader**

The Background Paper provides a preliminary overview of existing knowledge and scopes out the questions addressed by this Task Force. The analysis, conclusions and recommendations contained herein should be considered as very preliminary as they are likely to evolve as the Task Force works toward its final report at the end of 2004. Comments and suggestions are welcome. Please cite this paper as "Background Paper of the Millennium Project Task Force on Science, Technology and Innovation".

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**FORCE ON SCIENCE, TECHNOLOGY AND INNOVATION**  
**United Nations Millennium Project**

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## INTRODUCTION

This paper outlines elements of a global action program to apply science, technology and innovation (STI) to meeting the Millennium Development Goals (MDGs). For purposes of the report, STI is used to mean the generation, use and diffusion of all forms of useful knowledge as well as the evolution of associated institutional arrangements.<sup>1</sup> The MDGs include: halving extreme poverty and hunger, achieving universal primary education and gender equity, reducing under-five mortality and maternal mortality by two-thirds and three-quarters respectively, reversing the spread of HIV/AIDS, halving the proportion of people without access to safe drinking water and ensuring environmental sustainability. They also include the goal of developing a global partnership for development, with targets for aid, trade and debt relief. As a long-term vision, the idea is to see achieving the MDGs as steps towards longer term targets for developing global learning mechanisms, which facilitate the building of internal capacity in developing countries such that the institutions for learning can in the long run act as an engine for growth in these countries.

The MDGs include targets and the Millennium Project Task Forces are structured accordingly around issues such as poverty, hunger, primary education, gender equality, child and maternal mortality, HIV/AIDS, malaria, TB and other major diseases as well as access to essential medicines. In addition, the goals stress sustainable development, safe water, upgrading slums, open, rule-based trading systems and technology transfer. However, science, technology and innovation underpin every goal. It is impossible to think of making gains in concerns of health and environment without a focused STI policy, yet it is equally true that a well-articulated and focused STI policy can make huge gains in education, gender equality (often having to do with education and health care itself) or upgrading of living conditions. The Human Development Report (2001) placed gains in technical progress as the largest contribution towards reduced mortality rates and improved life expectancy in the period 1960-1990.<sup>2</sup>

Furthermore, there cannot be a robust science and technology policy if it is not underpinned by well-designed STI policies addressing learning, technology, technology transfer, R&D or commercialisation of technologies. This is particularly true in areas that have particular impact on education, health or environmental issues, such as agricultural and medical biotechnologies, pharmaceuticals, computer networks and telecommunication systems or issues of water and energy use.

Envisioning the fulfilment of the MDGs requires focusing on the *creation of policies and institutions* that facilitate the application of STI to each of the Goals (often

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<sup>1</sup>. In the rest of the paper, science and technology will be used as a shorthand to include all forms of useful knowledge derived from diverse branches of learning and practice ranging from basic research to engineering to traditional knowledge. Our focus is how this diversity of sources is brought together—especially through institutional organization—to solve practical problems associated with the MDGs.

<sup>2</sup> HDR 2001 pg 29

expressed in the form of technological capabilities).<sup>3</sup> It is this *learning process* that will form the basis of the work of the Task Force on Science, Technology and Innovation (STI).

This paper is divided into four sections. The first section provides the setting for the Task Force by outlining the linkages between STI and the MDGs. The second sections reviews key development trends and points to the importance of focusing on technological change as a major source of economic productivity. This theme is elaborated in the third section. This section presents the view that economic transformation is closely associated with social learning involving interactions between technological change and the associated institutional innovations. Using this as a conceptual basis, the final section outlines a global framework for using science and technological as an a tool for implementing the MDGs. The framework for action focuses on five key areas: improving the policy environment; building human capabilities; promoting enterprise development; investing in research and development; and looking ahead through foresight activities.

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<sup>3</sup>. The term “technological capabilities” encompasses the wide range of knowledge and skills required to acquire, assimilate, utilize, adapt, change and create technology. It includes knowledge of organizational structures and procedures, as well as behavioural patterns of workers and customers. For such capabilities to generate the necessary economic dynamism, they require certain complementary inputs that include organizational flexibility, finance, quality of human resources, support services and information management and co-ordination competence.

## **1. DEVELOPMENT CHALLENGES**

### **1.1 Setting the stage**

Technological change is at the heart of development worldwide. Yet, the conventional development advice meted out to developing countries is that they struggle (and fail) because of “poor governance”, usually associated primarily with governmental corruption and inability to develop or protect basic infrastructure. Fundamentally, we need to analyse more thoroughly the structural and institutional characteristics of the environment in which technological change occurs. While the governance of a nation is important to the story of development, one must interpret cautiously “bad governance” stories because they hide juxtaposition of good and bad, of gains on some fronts and failures on others, and because the broad-sweeping labels hide the process of micro-level change where institutions are created for long-term economic development.

For example, the common culprits for failing economies and low levels of overall development in Africa are usually attributed to war and corruption. Certainly, these factors can be, and have been, debilitating for economies and for political liberties that sustain long-term economic gains. Yet, we must not mistake desirability for necessity, or normative assumptions for historical reality of technological change. Some of our greatest economic and technological success stories of recent decades of the 20th century, those of the East Asian nations and economies like South Korea, Taiwan, Singapore, Hong Kong and more recently of some others, have had distinctly uneven commitments to human rights, gender equality or broad political freedoms. Indeed, the South Korean industrial rise is a story of not only building on a high level of commitment to education and education homogeneity but also building on the backs of exploitative gender dynamics in factories, and on crack-down of union voice and labour representation. Indeed, the East Asian successes are not about the absence of corruption (of which there appeared to be plenty), but of the nature of the institutions that were designed to facilitate local technological capabilities even when reliance on outside expertise was a cheaper option.

However, these are not the only technological and developmental success stories of the last century. Finland, for example, is a good example of poverty, even famine as late as the 1870s, extreme climactic conditions and lack of significant natural resources. Yet, it ranks today as one of the most R&D intensive, high technology economies of the world, and with one of the highest per capita publication rates for S&T and a high patenting profile.

A fundamental problem today is that past strategies no longer work unhindered. A host of “successes” have been analysed and disseminated, but the global rules governing market exchange and intellectual property rights have also changed, among others, causing developing countries today to face constraints that their predecessors did not. For example, Korea reached present industrial strengths through a vast array of import

protecting measures, along with selective barriers against foreign investments. These are difficult to accomplish under the present global trading regime. India's strengths in the chemical and pharmaceutical sector were also developed in part under the umbrella of a patent regime recognising only process patents. Although this was not at all unusual—many advanced industrialised countries did the same at earlier times in history—this option is less accessible because of the tightening of the intellectual property protection and other factors that limit technological spillovers.

In summary, we need to account for the vastly different structural environment in which technological change occurs. One manifestation is the existence of globalised production networks dependent on geographically dispersed cost and logistical differences. This signifies a big shift from a few decades ago when foreign direct investment (FDI) had other implications and modes of entry and impact. The second is the changed geopolitical climate that allowed certain countries preferential access to US and other advanced technology markets for new technologies, access to new export markets and significant amounts of development assistance. The third is the changed intellectual property regime already mentioned, which played such a critical role in early development of certain industries of advanced and newly industrialised countries. Finally, the information and communication technologies revolution, particularly the potential of the Internet in the way it links the world, and to some extent, biotechnological innovations, have created new pressures and opportunities on skill sets and organisational practices within enterprises, universities and other R&D and manufacturing sites.

In general, while we cannot possibly dispute the devastating effect on even good political climates of challenges such as war, civil strife and natural disaster, the analysis must focus on how gains are made on some fronts despite the challenges, and how certain institutions in other countries have prevented for instance wars, or made them politically unpopular options. The problems of development are more general, and wars are only one manifestation of deeper problems. ***Our question addresses in an inductive way how countries emerge from these challenges and what role the international community can play in assisting them in this growth.***

Governance debates alone cannot solve all development problems, even economic ones. Even if we were able to “fix” problems of “poor governance”, we would be left with moments in time at the cusp, where a lack of robust institutions that underpin the development process would eventually undermine any development hopes. In sum, “good governance” (and good government) is a necessary, but not sufficient, basis for long-term development, economic or otherwise. In particular, countries that have been told by international agencies and other countries that they would succeed if only they were able to depose a corrupt government, or if only they could call a ceasefire, or if they only follow a specific economic path (privatisation, opening the economy, etc.) are faced with serious disappointments along the road. Once the cessation of the “evil” occurs, these countries are left with even fewer options. The very destruction of present



debilitating causes also undermines institutions that also contribute to long-term growth-market, a strong government, judicial capability and infrastructure and scientific and technological solving-problems capabilities.

In particular, with economies devastated, these countries have little fallback resources of competitiveness and yet have devastating burdens of poverty to deal with. The lack of scientific and technological capability, or ways of building these assets over time, or processes that destroy accumulated skills, puts them significantly behind STI leaders, and the lack of these STI institutions and policies gradually undermines their position over time. ***Thus innovation policies that encompass both STI issues as well as the systematic institutionalisation of learning over time in industrial, agricultural and services sectors, is a vital part of any economic development, or reconstruction program.***

The conventional wisdom has interpreted the development of economies as one of capital accumulation, rather than one of investments in public and quasi-public goods, which includes STI. While the shift in thinking is gradually occurring to embrace the evidence that supports the latter analysis, shifts in technological regimes are not simple. An area within STI that resonates particularly well with shifts in national political and economic regimes is how to initiate changes in the technological regimes and support innovative technological niches.

From a geopolitical standpoint, a leading explanatory variable for induction into privileged circles of trade negotiation, economic treaties and preferential status, is the technological capability of the country. Rapid economic growth rates are a clear attractor of foreign attention, from the standpoint of potentially new markets for goods and services from leading industrial powers, to regional political power considerations (both China and India in Asia and Brazil in South America present good examples of increased inclusion into select economic and political clubs). Thus there is no substitute for scientific and technological bases, which under-gird everything from agricultural self-sufficiency to public health coverage to lucrative licensing options for indigenous technology advances.

The push to develop STI policies in a comprehensive way also allows for the creation of institutions that serve broader economic goals- a proactive State at different levels, innovative industries, strong research universities that are locally responsive, as well as regulatory, legal and financial capabilities that support STI. African countries like Kenya, the Republic of South Africa, or Tunisia, that have paid greater attention to these issues, have also been able to address broader issues of political and economic representation and social unrest. While their record is mixed, their industrial and STI base has provided a platform on which other learning institutions are structured.

While the benefits of technology vis-à-vis the governance framework, are usually laid out in terms of transparency of government through the use of information and

communication technologies, there are other ways we should consider how STI policies contribute actively to enhancing government. More educated populations are often more participatory, have greater economic clout and more constituent power. Different population groups can also interact with each other in ways that might have prevented national integration before.

Of course, STI policies when well constructed, also directly address pressing basic needs in agriculture, social services, water and sanitation or infrastructure. Where STI policies could constructively contribute to the analytical debate is to move beyond the antagonistic models of State vs. Society, or State vs. Markets. Instead, gains from STI can be used as a powerful leverage by States to sell their image, their legitimacy and the legitimacy of their means of consolidating power in their hands. By creating opportunities for “catch up” by developing countries on multiple fronts at once, STI policies can also insert countries into broader international collaborations and market opportunities.

## **1.2 The Millennium Development Goals**

At the Millennium Summit in September 2000 world leaders passed the Millennium Declaration, which formally established the MDGs. Since then the MDGs have become the international reference standard for measuring and tracking improvements in the human condition in developing countries. They have the advantage of (i) a political mandate agreed by the leaders of all UN member states, (ii) offering a comprehensive and multi-dimensional development framework, and (iii) setting clear quantifiable targets to be achieved in all countries by 2015.

This Task Force addresses the question of how science and technology can be enhanced and put to use to help all countries achieve the MDGs. The mission of the Task Force is guided by the understanding that most MDGs cannot be achieved without a strong contribution from a framework of action that seeks to place science and technology at the center of the development.

The objective of the Task Force is to propose strategies for how science and technology can help achieve each MDG. These strategies are not aimed to be a replacement for other approaches but are only applicable in cases where the use of science and technology is deemed relevant. For example, science and technology plays an important role in addressing challenges associated with poverty and hunger (MDG Goal 1) through its contributions to economic development, creation of employment opportunities (e.g., low-cost housing, manufacturing opportunities, agricultural productivity through new agricultural technologies, novel service models such as call centers); reducing hunger through enhanced nutrition, improved cash and subsistence crops, better soil management, and efficient irrigation systems. But these technological measures do not in themselves solve the challenges of poverty and hunger; they must be seen as complementary to other approaches needed to improve human welfare.

## **Box 1.1: Millennium Development Goals**

### **Goal 1: Eradicate extreme poverty and hunger**

**Target 1:** Halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day

**Target 2:** Halve, between 1990 and 2015, the proportion of people who suffer from hunger

### **Goal 2: Achieve universal primary education**

**Target 3:** Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling

### **Goal 3: Promote gender equality and empower women**

**Target 4:** Eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015

### **Goal 4: Reduce child mortality**

**Target 5:** Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate

### **Goal 5: Improve maternal health**

**Target 6:** Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio

### **Goal 6: Combat HIV/AIDS, malaria and other diseases**

**Target 7:** Have halted by 2015 and begun to reverse the spread of HIV/AIDS

**Target 8:** Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases

### **Goal 7: Ensure environmental sustainability**

**Target 9:** Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources

**Target 10:** Halve, by 2015, the proportion of people without sustainable access to safe drinking water

**Target 11:** By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers

### **Goal 8: Develop a Global Partnership for Development**

**Target 12:** Develop further an open, rule-based, predictable, non-discriminatory trading and financial system

**Target 13:** Address the Special Needs of the Least Developed Countries

**Target 14:** Address the Special Needs of landlocked countries and small island developing States

**Target 15:** Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term

**Target 16:** In co-operation with developing countries, develop and implement strategies for decent and productive work for youth

**Target 17:** In co-operation with pharmaceutical companies, provide access to affordable, essential drugs in developing countries

**Target 18:** In co-operation with the private sector, make available the benefits of new technologies, especially information and communications

Science and technology can also play an important role facilitating implementation of the MDGs on education, gender, health and sustainable development. Information and communications technologies (ICT) can contribute to secondary and tertiary education through the use of distant learning devices as well as remote access to other educational resources and other solutions. Many technologies hold the promise of significantly improving the condition of women in developing countries (e.g., improved energy sources, better agricultural technology, increased access to water and sanitation). This is particularly important in areas where women play dominant roles. A broad number of required health interventions require the development of new treatments and vaccines through improved science (e.g. anti-malarials, HIV treatment and prevention, multi-drug-resistant tuberculosis, vitamin and other micro-nutrient deficiencies in children and mothers, etc.). In addition, the production of generic medicines holds the promise of improving access to essential medicines by the poor. A particularly important contribution of science and technology to this field will lie in improved monitoring systems for drug quality.

Improved science and technology at the local level will be indispensable for the monitoring and management of complex ecosystems such as watersheds, forests and the seas. This will help predict and thereby manage the impact of climate change and biodiversity loss on these ecosystems. Access to water and sanitation will require continuous improvement in low-cost technologies for water delivery and treatment, drip irrigation as well as sanitation. Lasting improvements in the lives of slum dwellers will only be possible through achieving the MDGs in urban environments and thereby necessitate advances in all areas of science and technology.

The outcomes of the World Summit on Sustainable Development (WSSD) have amply demonstrated the importance of science and technology. However, the scientific, engineering and technology community has yet to be development motivated. For example, it is a sad fact that while we have very capable engineering organisations and expertise available when natural or other disasters strike, we do not have the same levels of commitment, expertise or scale for more “normal” problems of development worldwide.

The field of energy offers another example of the role of science and technology in sustainable development. The affluence of developed nations rests on the generous provision of energy; much of the deprivations suffered in developing nations stem from its lack. Oil is probably the fuel where the future beyond the next 20 years is most uncertain. Gas will cover projected needs for rather longer, and coal for at least until the end of this century. Eventually there will be a problem of supply. It is unlikely to be the major driver for change for the next two or three decades at least.

But of course ultimately the use of fossil fuels is unsustainable. What we burn will not be available to future generations. Burning fossil fuel results in the emission of CO<sub>2</sub> and an

enhancement of the greenhouse effect. The single most important component responsible for about 80% of the climate warming is of course CO<sub>2</sub>. The aim in the current energy debate is to reduce the emission of greenhouse gases. The simplest approach is to use less energy. The opportunities for doing so arise in almost all human activities and not least in domestic usage. It is an intriguing goal—the only approach to the overall problem which has no evident downside. The main problem is that energy is cheap in the developed countries, which reduces the enthusiasm for using less.

### **Box 1.2: Sustainable development and engineering organizations**

A number of international engineering organizations play important roles in international development. For example, the Registered Engineers for Disaster Relief (RedR) that have worked in the forefront of refugee relief in all the hot spots like Bosnia, Kosovo, Angola, Rwanda, Cambodia etc. RedR manages a register of carefully selected engineers who can be called on at short notice to work for front-line relief agencies. However, RedR has yet to spread into the developing world where it could play an important role building local engineering capabilities. Efforts are now being made to extend it worldwide as it is realized that the immediate response to any disaster situation is a well-trained corps of local engineers.

These efforts are complemented by national examples around the world. The China Association for Science and Technology, which is the largest non-profit science and technology organization in China, commissions a special-purpose train with frequent stops in poor rural areas with explicit focus on applying S&T for basic needs such as conducting surgeries, solving technological problems and giving lectures. It also hosts a mobile exposition with learning materials to spread the interest in science and technology across areas that need it most.

There is thus no alternative but to develop small power plants, units and systems that are environmentally-benign. The medium term prospects are promising. An August 2000 issue of the Economist featured a most encouraging report on small power devices and systems, showing the economical viability of hydrogen fuel cells and micro turbines. There is a dramatic increase in venture capital investment in USA. The giant power manufacturers like General Electric, Siemens, ABB and giant oil corporations are investing in fuel cells and renewable energy. For instance, BP has not only made a big shift towards natural gas but also placed hedging bets on renewable energy and hydrogen fuel cells. This is attributed to the deregulation and privatization of the electricity supply market. The European Union has made a big political push for renewable energy. It is forecast that the share of renewable energy in electricity generation in EU countries will increase to 10-30% in 2010 from the current level of less than 5%.

For the 2.0 billion people mostly in the rural areas of the developing world currently without access to commercial energy and for the 4.0 billion to be added to the world's population by 2100 mostly in urban centers in the developing world, the over-riding energy issue is access and affordability. In the light of current promising world

development with regard to new and renewable energy options, scarce capital should not be expended in developing countries on the development and expansion of power grids and the concomitant installation of large and conventional fossil-fuelled power generating units. Money will be better spent in new, renewable and environmentally benign power generating devices. The developed world can contribute by making available now the technology of small power generation devices that are deemed not sufficiently energy efficient by their high and stringent standards and are either rejected or subject to further R&D. Such devices may be of immediate application for the developing countries that are not concerned so much with energy efficiency but energy accessibility and affordability.

### **Box 1.3: Powering future cars**

The RAC (Royal Automobile Club, UK) Foundation (2002) has recently carried out a major study into the future of motoring – towards 2050. It states: ‘The 2050 car will look relatively familiar from outside. The average European car of 2050 will be much the same size as today’s, and will weigh about the same. It will however embody many features which will make it more versatile. It will have a fuel cell power-train, almost certainly using compressed hydrogen gas as its fuel. Thus its on-road emissions will be zero, except for a small amount of water vapour. Its energy consumption will be substantially less than half that of current cars, and it will be exceptionally quiet, which will highlight the need to extend the adoption of ‘quiet’ road surfaces to urban areas’. What is even more promising is the active participation of all the motor vehicle manufacturers, demonstrating in no uncertain way that fuel cells for cars will be a commercial reality. Daimler Chrysler expects to have fuel-cell cars on the market by 2004. Honda, Toyota and General Motor also say their fuel cell cars will be ready by then. BMW has recently unveiled a prototype version of its 7-Series saloon car with hydrogen-power internal combustion engine.

Source:

Transport has a major sustainability dimension. In the developed world there is great anxiety about the impact of increasing wealth in the ‘developing world’ leading to massive increases in car ownership, and thus to greatly increased levels of pollution—local, regional and global. The developing world, not unreasonably, is reluctant to accept advice that it must adopt pollution-free methods of transport that the developed world has ignored. Transport is a massive consumer of energy and it has profound environmental impacts, yet modern lifestyles depend on modern transport systems. The motorcar produces pollutants, which contribute to the greenhouse effect, to acid rain, to health problems and to a range of issues associated with ‘quality of life’ including noise, community severance, and visual intrusion. The conflict between economic development and protecting the environment pervades the transport debate.

While there can be little doubt that hydrogen will be the most positive development for energy and transportation in sustainable development, we need to prepare developing countries for its short term economic and employment impact, possibly adverse, on their

petroleum production and distribution industry and their motor vehicle manufacturing and indeed their whole energy and transportation infrastructure as well as the exciting prospects on cost saving on environmental pollution measures and opportunities for new industries. Scientists and engineers from developing countries should now participate actively in the R&D efforts in developed countries. This is one of the best ways to transfer technology and spread technological awareness regarding hydrogen fuel cell in developing countries.

The MDG (Goal 8) related to global partnership has both explicit and implicit scientific and technological implications. The ability of developing nations to participate in the global trading system will depend to a large extent on their capacity to generate new products and enhance their competitiveness. But their capacity to invest in new technologies is in turn influenced by openness of the global trading system. International partnerships involving the youth could play an important role in spreading the benefits of emerging technologies.

#### **Box 1.4: Tapping the energy of youth for growth**

There are already a number of existing programmes that tap into the energy of young professionals in the international, non-governmental and UN arenas. Within the United Nations, UNESCO formed the International Forum on Young Scientists during the World Conference on Science, Budapest 1999. The UN Program on Space Applications has formed the Space Generation Advisory Council (age 20-35). The World Bank (age<35), the OECD, the FAO (age<35) and the ILO (age 25-35) all have young professionals programs, designed to both develop and learn from young professionals around the world. Regionally, groups from the Asian Coalition for Housing Rights and the London Business School have young professionals and many of the main organisers of NGOs are young professionals themselves. There are also a large number of existing young professional networks around the world that can be immediately engaged, from the Waikato Young Professionals in New Zealand, (age 25-35) to networks in Pittsburgh, Philadelphia, Chicago and Toronto (age 25-40), the Thai American Young Professionals Network (age 25-35) and Young Professionals Keshet (age 25-35). These networks are diffused. Their main focus is professional development. With the right assistance from the UN, International Development agencies, Governments and Business Corporations and with young professionals driving their own networks and organizations, they will be the most portent force in achieving the MDGs. A good example is the Australian Young Ambassadors for Development Program, which places young professionals in developing countries, sponsored by AusAid and organisations in both Australia and the recipient countries. Extensions of this concept could include two-way exchanges of young professionals, like the reverse Colombo Plan fellowship scheme of Malaysian alumni of Australian Universities that brings young Australians to study and work in Malaysia.

The typical young professionals are aged 25-35 years old, and are in the early stages of their career, with, or seeking employment of some description. Young professionals comprise around 15% of the world's population and nearly a quarter of the world's

eligible work force. In the developed world they may have few commitments or a young family, and may have access to a large disposable income. In the developing world young professionals are some of the main drivers behind the economy, supporting families and the community in general. In the current knowledge economy a large proportion of young professionals have become captains of cutting-edge industries.



## 2. DEVELOPMENT TRENDS

### 2.1 Regional trends

There are large differences between regions of the world in the ways in which they have faced historical economic, political and social challenges. These differences, and the priorities for economic development that they induce, are visible not just in developing countries, the usual focus of international economic development efforts, but also within regions in the developed world where sub-regional disparities are substantial. For example, Europe, although overall prosperous, suffers from pockets of relative poverty and lack of access to basic amenities and representation of peoples. Huge countries like China, Brazil or India, suffer both national-scale poverty, but also hide huge sub-regional variations in social, economic and political fortunes. East and Southeast Asia have regional crests and troughs economically and politically. Myanmar, Laos, Cambodia have not enjoyed the same economic growth as other East Asian countries.

Within our own lifetimes, the countries of East Asia have generated extraordinary economic success in recent decades, often accompanied by a substantial improvement in equality, particularly through access to education. At the same time, gains made in earlier decades within countries of the former Soviet bloc have been eroded to different extents, particularly within the former Soviet Union itself, where life expectancies and public health infrastructure have badly suffered along with the decline of legal, financial and political institutions. Sub-Saharan Africa and South Asia have not fared well, although pockets of visible economic and political strengths have emerged in these regions.

But, in painting regions with the same brush, we run the risk of losing the details that make for institutional learning and micro-environmental change that leads to long-term economic and development gain. We have mentioned earlier how East Asian countries diverge in the ways they approached the microeconomic details of their industrial paths; indeed, their macroeconomic paths looked very similar. *The devil is in the details. We learn a great deal from failures as well.*

Within the MDGs, there are certain pressing regional trends that need attention. For example, many African and South Asian countries are facing severe HIV/AIDS and TB problems, with the former exacerbating what was thought to be a relatively well-controlled TB phenomenon in many areas. In addition, malaria continues to be of serious concern with high mortality rates in most tropical regions (and worsening in parts of Africa), which also suffer high poverty rates and poor health infrastructure. The STI policy focus needs to be oriented towards finding vaccine solutions while also creating new institutional mixes from which new research collaborations can spring.

Overall, progress has been made by developing countries on poverty with the average percentage of people with income of less than \$1/day decreasing in one decade from

32% in 1990 to 25% in 1999. But most of this decline is accounted for by progress in East Asia—mostly China, and thus paints a grimmer picture for most developing countries. Globally, education indicators are also not on track to fulfill the MDGs, even more so if we take into account gender inequalities in type of education and by region (see Vandemoortele, 2002). Predictably, these are serious problems in South Asia, Sub-Saharan Africa, the Middle East/West Asia and North Africa, all regions of significant societal inequalities between men and women.

Child mortality rates also reflect the gender inequalities and regional disparities as does child and adult malnutrition. The same trend applies to HIV/AIDS and other public health problems, where girls and women are likely to suffer the most. This is also reflected in high maternal mortality rates in many of the same regions.

A region that deserves special attention is Africa, where economic development indicators show a wide range of fluctuation and where sub-Saharan Africa has moved into the 21<sup>st</sup> century with some promise. Yes, per capita income levels are only a third of those in S. Asia, another poor region, and 48 sub-Saharan countries together account for the GDP of an industrialised country's output from a town of 60,000, according to the World Bank. (IBRD/World Bank, 2000)

Overall, both savings per capita and income have declined since 1970, and have not been assisted by environmental losses compounded by rapid population growth in some sub-regions. Other basic needs are also not met: food, water, sanitation and public health access need significant attention. War civil conflict and natural disaster also threatens the region. Gender inequalities are rife, with women constituting well over half the labour force in some countries, but facing dire lack of access to basic amenities.

Thus, Sub-Saharan Africa's priority areas may be seen to lie in a huge push to satisfy basic needs while at the same time building up the institutions that support a thriving private enterprise sector in manufacturing and services. But agriculture also needs attention. Governments in the region also vary sharply in the extent of state reforms that have been undertaken while also giving non-governmental actors an institutionalised role for the future. ***In short, we need a multi-pronged approach, stressing the interconnectedness of the policy reform process and the creation of institutions.***

In particular, any reform process must account for the need to foster a robust private enterprise sector, with all its accompanying financial, legal and political institutions. Within this process, we need to be particularly conscious of the significant economic role women and the young already play in the economy, although largely unrecognised by statistics or policies. Higher productivity growth could be an aim in itself, because this region of Africa does need higher economic growth rates to make any real dent in basic needs of the population, but more importantly, private enterprise growth could allow the building of long-term institutions that have an impact on other aspects of sub-Saharan societies—in civil life, production across sectors and in the government.

While both governance and the HIV/AIDS issues have received attention as Africa's crisis points, in reality, there is a delicate play of cause and effect with a weak institutional structure also undermining gains that might have been made on these two fronts. ***Many countries in the area have instituted macroeconomic reforms, but there needs to be much more micro-level attention given to the structure, environment and growth potential of producers at the local level.***

While we deliberate the appropriate STI policies for countries in these regions, we must be conscious of the fact that a "good governance" approach alone will not sustain us. Investments in people's health and health infrastructure, (especially with regard to the AIDS epidemic) is critical to sustaining their engagement in political reform and economic activities, while allowing these countries to become free, long-term, from crippling foreign debt obligations and low growth rates.

But investing in people does not simply mean rising per capita spending, although this also would be desirable. It requires building up the State and enterprise capacity (particularly private enterprise) to take on additional economic and political responsibility while being able to identify new opportunities for economic growth. Particular attention must be given to enhance people's capabilities to solve problems through a strong and sustained effort on education. While growth alone will not solve the region's problem, it is a necessary condition for advancement or gains made to date will eventually be eroded.

***An STI thrust that takes into account the fact that basic needs and competitiveness are intertwined will recognise that sub-Saharan Africa's problems are ones of institutional interconnectedness.*** In the learning framework, this means that the loci of learning within enterprises must go hand-in-hand with the government deliberately investing to institutionalise this learning (and itself learning along the way). We cannot discuss the AIDS epidemic in Africa without paying attention to economic opportunities for the labour market, or of problems of weak government. However, we can specify how the STI base can create technological and institutional innovation that assists a multi-pronged approach.

Fundamentally, countries themselves need to set their priorities, but to institutionalize the learning process that governments, private actors, universities and non-profit groups go through, there needs to be explicit attention paid to deliberate investments in skill-building and in the enhancement of institutions that sustain learning in the long-term. While technology transfer is one possible way of acquiring technology, we know this is neither a costless nor entirely clean process. Importantly, "full" transfer is inherently impossible for a variety of reasons, not all of which have to do with absorption capacity, but more with the tacit nature of knowledge itself and the mechanism by which learning transfer occurs. Whatever the choice along the spectrum, it follows that corresponding political and institutional choices are also necessary. Even if developing countries were

to structure their learning through doing everything by self-production, this “learning-by-doing” does not arise entirely spontaneously; a large component still requires conscious investments in building indigenous innovative activity (see Pavitt, 2002).

Finally, countries and firms (and governments) are all affected by STI policies and the institutionalization of learning, but to different degrees and in fundamentally different ways. They also have different capacities and limits in achieving this learning. Thus, as we structure the guidelines, we need to be mindful of these fundamental organizational and institutional differences of the unit of analysis and the agency of economic development. In addition, there may be varying degrees of control we have over the process of acquiring knowledge as manifested by technological understanding (being strong and reliable) and the knowledge manifested as organization routines and practice (weak and unreliable). (See Pavitt 2002 discussing Nelson 2000).

## **2.2 The macro/micro false dichotomy**

The historical basis for targeted industrial and STI policies has been, among others, to develop micro-based strategies that are built on strong local, institutional foundations. These were meant to create both national institutional capacity-development banks, research laboratories and universities, small and large firms alike and departments for technology transfer, as well as localized centres of excellence. Countries varied to the extent that they succeeded in both the former and the latter. Certainly, there are few developing countries where local capacity existed without national institutional capacity existing first.

Moreover, national policies and the institutions they created did not preclude the need for micro-institutions, both in scale and location. *However, a huge gulf has emerged in the dichotomies between policies espoused for the advanced industrialized and the developing worlds. In the former, the focus and support has been with micro-level details, while with the latter macroeconomic policies have taken predominance.*

While there is no separation between causes and effects in the relation between macro and microeconomic policies, using one or other excessively has only led to skewed emphasis on where innovation is supposed to lie. Indeed, conventional economic policies seem to have overly stated the degree to which macroeconomic policies determine the outcomes of industrial policy. Both Korea and Taiwan, for instance, relied heavily on sustained microeconomic “imperfections” in that they targeted industries, meddled with loan decisions, preferentially allocated credit to good performers (particularly for good exporters), relied heavily on the public sector for industrial development, and did not liberalise imports until well into the 1980s. Their main common features on the macroeconomic front were an orthodox interpretation of fiscal issues and foreign exchange.

However, the microeconomic strategies though broadly common, differed considerably from what the free-market pundits espoused. These distinguished the East Asian experience, more broadly, from the Latin American ones. Countries like Argentina and Mexico were both conservative macro-economically as well as micro-economically, and from a technological capacity and innovation standpoint, they look considerably different from the East Asian countries. Countries like India did not suffer from macroeconomic imbalances until the balance of payments crisis of the early 1990s. This has been followed by both macro as well as micro-level initiatives to foster technological growth.

In the case of India, many of the micro-level institutions have much to do with both centrally led efforts to build distributed capacity locally as well as state government-led efforts to compete with each other and lure investments, create technology transfer and assist domestic companies. This has been particularly visible in the Southern states of Andhra Pradesh (Hyderabad) and Karnataka (Bangalore), which have seen competition and success in both computer services, as well as emerging biotech competence.

### **2.3 Technology transfer**

The STI framework allows us to think strategically of different ways in which scientific and technological knowledge is acquired, retained, diffused and improved upon. The 1960s and '70s generated a somewhat utopian view of technology transfer from industrialised to industrialising countries, but subsequent evidence has highlighted the over-simplistic models on which these visions were based. While technology development is a relatively uncluttered and uncontested concept, the same cannot be said for technology transfer, which is neither costless nor straightforward. The more recent literature on technology transfer is pessimistic, yet hopeful. On the one hand, there is the idea that transfers from North to South are inherently limited given a variety of causes. On the other hand, this forces both Southern and Northern countries alike to be concerned (perhaps for very different reasons) about how to spur endogenous innovation in the South, while still benefiting from the existence of and access to mature technologies worldwide.

In the past, technology transfer had been wrongly focused at the high end. For achieving MDGs, mature and down to earth technologies like mechanisation of small farm, small-scale irrigation and potable water installation, small energy system, rural road to market and basic communications and computer facilities would be most telling. Similarly, technologies that enhance the productivity and profitability of SMEs would provide wider employment opportunities and better income equity. The reorientation to appropriate technology would not only require increased funding from developed countries, but also a paradigm shift from political leaders and intelligentsia including S&T elites in developing countries from investing prematurely and wastefully in high and cutting edge technologies and related R&D. By learning from those who have successfully gone before would also improve South-South cooperation.

***In essence, technology, taken in its broadest sense is a knowledge system, only one of whose elements is actual physical technology and equipment.*** It relies heavily on modes of learning, on adapting to new technologies, on educational systems, the STI as well as industrial policies, the nature and composition of the private sector and the capabilities already inherent in the public sphere. It also depends heavily on the flows of knowledge, resources and people between public and private domains of knowledge and the mechanisms by which information on specific innovations is shared, developed, commercialised and diffused. The incentive structure that causes different parties to become involved and stay committed also needs careful attention by policy makers.

Furthermore, the knowledge system or technology is embedded in a wide array of global institutions defining the scope and use of new technologies and influenced heavily by first-movers and their concerns. Countries may thus not be in full control of how they channel technologies to certain domestic sectors, nor in which markets they sell the technologies once they are developed.

## **2.1 Market failure and innovation**

A standard market failure model for State intervention argues that the latter must be a last resort and adopted only in the cases of public goods, externalities, information asymmetries, etc. However, it is a well-known fact that most STI policy measures and the goals they seek to achieve are rooted in the simple case of common resources, public goods outcomes and the mitigation of negative externalities. (The positive externalities case can be absorbed analytically under public goods availability). Market failure modes of even this simplest type can prove paralytic for the development and diffusion of new and useful technologies relevant to the developing world.

Dependence on markets alone would create a demand function representing those with purchasing power, i.e. able to “voice” their vote through the exchange mechanism of markets, and these markets are often flawed through unequal representation (not just on the basis of income) in the exchange mechanism itself, unequal information and unequal risk to certain technologies. ***Technology markets face failures even in advanced industrialised countries, which have functioning markets, robust institutions and clearly delineated intellectual property rights.***

For example, a common example of why markets alone cannot solve all development problems is illustrated by the case of malaria vaccines that have yet to come on the market. Above all, markets for such products often are absent altogether or highly underdeveloped. This is the extreme market failure mode. There are a host of other reasons even in functioning markets why failures might arise. Firstly, most people needing the vaccine are poor, and are not an immediately attractive option for firms

targeting high profit margins.<sup>4</sup> Secondly, many poor people, unlike rich retirees in the advanced industrialized world, to capture a stereotype, are often not able to organize effectively to lobby their governments for cheaper drugs or more relevant medicines for their ailments. Thirdly, information asymmetries are rife in the pharmaceutical industry, with developers of the medicines often having access to significant information and knowledge of new technologies. And of course, the usual arguments for “standard” market failure also hold, i.e. public goods and externalities.

***To summarise, one needs to also survey non-market institutions and models.*** It means looking at the experiences of those countries that have gone before and “made it”, Finland, Korea and Taiwan being good examples, to show us that ***development is not simply about structuring the institutional mix to become “more perfect” (read less government), but in fact may require specific types of policies which are quite interventionist by free-market standard.***

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<sup>4</sup> Although, one could make the case for high-volume sales still being relevant There is also evidence to indicate that the poor in fact do spend a large fraction of their income on health i.e. health spending is a regressive function of income.

### **3. SCIENCE, TECHNOLOGY AND INNOVATION**

#### **3.1 Historical outlook**

An analysis of Western economies and their history suggests that the prime explanations for the success of today's advanced industrialised countries lies in their history of innovation along different dimensions: institutions, technology, trade, organisation, application of natural resources. In particular, the characteristics of innovation itself: "uncertainty, search, exploration, financial risk, experiment, and discovery- have so permeated the West's expansion of trade and the West's development of natural resources as to make it virtually an additional factor of production," (Rosenberg and Birdzell, 1986). It is in the process of innovation that the institutions appropriate for further innovation are strengthened.

Thus, scientific and technological innovations come about through a process of institutional and organisational creation and modification, one does not precede the other neatly in time. Certainly, defining characteristics of the Western growth rates have been the institutionalisation of private enterprise along with its financial and legal rubric, along with constantly attaining to lower cost of production and introducing new products on the market. There was also an exploitation of opportunities provided by trade and natural resources. This was a tribute to not just carrying through with new opportunities, but the abilities of the private sector and the State alike, for recognition of the new opportunities and ways in which to exploit them. The rise of science and technology, particularly the institutionalisation of the scientific method in the 17<sup>th</sup> century, also created a forum for shared experimentation, exchange of findings, and advancement and refinement of method. It was, in fact, a celebration of experimentation and uncertainty through the patronage of risk-taking and by the rewarding of discovery.

These were manifested eventually in the transformation of organisational types in the private sector as well as in new institutions that could weather uncertainty over time in economic circles, in particular. Incentives for investment followed. What is characteristic of this history is the novelty of products, services, organisations and institutions being created suitable to the local microclimate, but also the sheer diversity within the range of such products, services, organisations and institutions. In the current globalised world, developed countries and their corporations tap the world's natural resources, have access to the best and brightest in human resources from all round the globe, manufacture in the most cost effective locations and have the whole world as their market. Indeed the world is their oyster.

However even within this framework, our most recent successes lie in the newly industrialised nations and economies in East Asia, where again high growth rates were certainly a necessary part of the story, but were buttressed by diverse and adaptable institutions that oversaw new production regimes, export-orientation, compacts between State and private enterprise. For sure, it was also a period that saw repression of other



institutions of labour and gender, for example. What particularly stand out were the deliberate choices made by governments in some cases, and rapid adaptation to changed economic circumstance in others, that allowed producers significant rewards while also requiring a certain commitment to national goals. Legitimacy for the governments was derived in part by higher economic growth rates. Economic development became a vehicle for buttressing democracy, both South Korea and Taiwan elected and are now governed by Presidents from the previously opposition parties without adverse effects on economic growth.

The Finnish example is also telling in terms of STI policies and institutional building: the establishment of the Centre for Promoting Technology, in 1983, particularly strong in microelectronics; the establishment of technology centres that have united the interests of municipal authorities, local universities and local firms; venture capital and development companies managed by Parliament; a strong push towards science and technology vocations, resulting in no less than a half of the total amount of degrees annually granted either at universities or technical colleges in engineering and natural sciences. As a result of all this Finland showed a fair score in terms of trade concerning products of high technology already in the '80s, surpassing Norway and paralleling Denmark (Ahonen, 1995). From a developmental point of view, the Finnish example shows that it is possible to harness sound STI policies to sustainable economic growth and, in the same movement, to pay strong attention to equality concerns. Moreover, in some sense, the latter seems to have been a prerequisite regarding the former.

### **3.2 Technology, innovation and income levels**

Technology affects human development through two major paths (see UNDP HDR 2001). Through innovation, it can (a) directly affect human well being by increasing functionality of existing means to reduce poverty and increase human capabilities. This is most evident through technological innovations in human health, agriculture, and energy use and information and communication technologies. (b) It can also indirectly affect human well-being by enhancing productivity and thus economic growth and incomes. This productivity enhancement may be seen through increased output of workers, higher agricultural yields and heightened efficiency of services, while the higher incomes can again help to meet basic needs *Thus S&T helps directly, even without direct income increases, although it can help the latter as well. Importantly, it assists in overcoming the barriers of low-incomes and weak institutions.*

*Conversely, human development itself strengthens technology development. We cannot talk about competitiveness or increased capacity or productivity of industries, agriculture or the services sector without referring to the critical components that make up such systems: people and their knowledge.*

An important driving force of the adoption of technology, whether old or new, is higher income, but it is circular to argue that technology depends directly on higher incomes,

when in fact technology may be a cause, not a result of increased uptake. An important additional point is that innovation itself may not be necessarily driven by higher incomes, but may fall out as a result of the adoption of certain technologies, which in turn may not have to directly do with higher incomes.

In summary, while it may help to be richer, the evidence is fuzzy about whether this is a result or a cause of technology use and diffusion. Indeed, innovation may thrive on increased resources being thrown at the problem, particularly finances, but it is no guarantee that innovation will occur. However, in developing countries, without funding, innovation through S&T will hardly occur. In this sense, higher funding is necessary, but it is certainly not sufficient. The specific institutional mix of actors – individuals, firms, the State, other organizations, all serve to determine the milieu in which an innovation occurs within a specific technology.

The mutually reinforcing thrusts of human development and technology development serve to create a basis for a relationship between certain technologies and specific aspects of human development. For example, medical breakthroughs are linked to basic health, cheaper medicines and lower mortality rates; higher food production through better seeds, water sources and more efficient and less toxic fertilizers, is linked to better nutrition (particularly since most poor families around the world are farming families); ICTs serve to enhance information and participation through telephone, radio, TV, fax and increasingly computers; and finally, manufacturing technologies drive industrial expansion, employment and labour incomes.<sup>5</sup>

***Yet, in addition to this seeming one-to-one relationship between certain technology advances and human development, each of the separate technology advances acts to reinforce the others.*** This is especially visible in medical technologies, where breakthroughs in genetics, coupled with computing advances, has opened up the world of drug discovery, development and manufacturing. Similarly, the advances in ICT technologies have themselves fuelled further gains to farmers and the manufacturing and services sectors. The list goes on.

### **3.3 Technological learning and public policy**

#### *3.3.1 Innovation systems*

We can learn something by looking within innovation “systems” and determining what varies in the institutional mixture, what is local and what is external.<sup>6</sup> If we thus look within countries, where we can posit that the innovation “system” has some common features and then look at regional variations where technological dynamism is visible,

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<sup>5</sup> Many medical breakthroughs can potentially raise the cost of diagnosis and treatment, so we tread a fine line in the management of technological innovation once it occurs.

<sup>6</sup> Indeed, “systems” may not be the most appropriate framework, because they suggest a closed entity, but one needs to think of “open” systems, whereby new actors and institutions are constantly being created, changed and adapted to suit the dynamics of scientific and technological creation.

we have moved from the national to the local without losing elements of either. Regional variations in innovation levels, technology adoption and diffusion and the institutional mix, can be significant.

The WDR 2001, for instance, highlights innovation regions around the world. India is a classic case in point. While there are plenty of skilled scientists, engineers and doctors around the country, Bangalore is listed as the prime innovation hub, and Hyderabad an emerging one. This is a case where skilled professionals in a developing country gravitate to regions with adequate facilities and enabling environments. Thus, the national policy environment, while defining the early basis on which these city centres became competitive, has given way to an increased local innovative policy and entrepreneurial climate that have generated significant computer, telecommunications and more recently, pharmaceutical and biotechnology outputs.

While the jury is out whether it is the local State governments or the private entrepreneurs who have been more relevant to this process, suffice to say that most people agree that the above two actors, large and small firms, universities, government laboratories have all had a part to play. It is perhaps easier to identify what does not make for innovation, rather than what does. Importantly, even if local environments are important for technological innovations such as malaria vaccines, wireless internet distribution and access, or using Global Positioning System (GPS) technology for farming or fishing, they are all faced with the challenge of keeping up with increasingly stringent global regulatory environments.

In the pharmaceutical industry, for example, this may be reflected in food and regulatory rules and certification for manufacturing facilities and output quality that may be administered differently by market and by new trading rules and WTO guidelines. In the information technology and telecommunications industry, this may be pressure from network externalities and the need to tie in to critical mass usage of a certain system or standard. Thus, neither innovation alone, nor even cutting edge technology, determines the eventual market uptake of the technology or the ability to keep up with regulatory pressures.<sup>7</sup>

New models have been advocated that identify the State, private sector, and university/research centre, as important parts of a larger system of knowledge and interactions that allow diverse actors with varied strengths to come together around common broad goals for innovation. In many developing countries, the State and private sectors have varying capacities. The State often has the greatest capabilities, built through a history of import-substitution policies, when the public sector had a

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<sup>7</sup> A classic US example is the standoff between Betamax and VHS, and we know which won the video standard race, even though many agreed that Betamax might have had superior technological advantages. In the developing world, more serious implications arise when the technologies and their applications affect food, health or education. The lack of impact of STI policy on the even wider diffusion of Oral rehydration therapy (ORT) or the Internet, are causes for concern and the need for commercialisation and distribution of these technologies may need country-by-country analysis and policy support.

predominant role. On the other hand, private sector capacity for adapting tacit knowledge and mature technology and for absorbing new knowledge has varied by country, region, and by sector.

Universities, on the other hand, have largely languished across the developing world, with an unclear mandate, limited funds and lacking the flexibility to metamorphose to meet either basic needs (often dealt with by public research centres in “mission mode”) or competitiveness (dealt with by the private sector or government training institutes). Although they have not been in the vanguard of development in many developing countries, they share with those of more advanced countries the new wave of demands towards more social accountability and more direct service to economic growth.

However, they often lack both the resources and the demand from a sound productive sector eager to benefit from the knowledge they might create. They suffer, thus, from a “loneliness syndrome” from which they alone cannot escape. To reverse this syndrome is one of the real challenges for development, one that cannot be fulfilled by pushing universities to change while everything else remains the same. A better approach is to channel energies within the university environment to fulfil a combined research, teaching and application mandate, with different types of universities taking on different challenges and government and industries engaging in effective interaction with them. This is not a path without dangers, however. One of them is that the pendulum (to mix metaphors) could swing too far in the direction of making universities simply outposts for government or private sector service functions, or engaged entirely in applied research. ***Any informed science, technology and innovation policy needs to account for the fact that universities must continue to have local relevance while still fulfilling broader mandates of education and knowledge acquisition and diffusion.***

Using a system of innovation approach (Freeman, 1995, Lundvall, 1988, for example), we could *ex-post* analyse both the Western and East Asian successes as characteristic of the “right” mix of institutional, technological and organisational elements that have given rise to STI, product, process and institutional dynamism. The challenge for underdeveloped countries is to re-think this powerful approach to adapt it to their specific conditions while bearing in mind the factors that make it particularly well fitted for development purposes: it explicitly acknowledges the political as well as institutional and cultural aspects of innovation processes; it stresses the importance of interactions between actors and organizations; it takes into account multiple actors with different roles, allowing to go beyond the dichotomy “state or market”, making room for more “bottom-up” and associative networks; it highlights user-producer interactions, assigning an important role to usually neglected actors as workers or consumers.

In China, where a blurred line exists between transitional forms of public and private enterprise, the challenge for government and the “private” sector alike has been to move from one set of institutions developed within the era of centralised economic planning, to another set, which is more market-friendly. The challenge in China has also been to distribute evenly the gains of economic success across the population.

In Latin America, many governments have collapsed in a spiral of macroeconomic troubles fuelled by social deprivation, falling confidence levels in both economy and polity, and low investments in institutionalising learning successes. Innovation in the sense of new products, processes or institutional creation, has been at best sporadic. Thus competitiveness has fallen, and with it, the ability of governments to provide for basic needs has also fallen. Undoubtedly, capital flight from the region and the difficulty in attracting new investments has exacerbated existing rigidities. Yet, countries like Brazil and Mexico have made systematic attempts over the years to upgrade industry, access new technologies, and invest in education and training particularly for the industrial class. However, the downside is that the latter, however, particularly when higher education is taken into consideration, continues to be extremely elitist, for far less than 20% of the young people in higher education age reach tertiary studies, against 50% average in OECD countries. Regional attempts at science, technology and broad-based innovation exist; but they need to be revived and given a broader mandate and platform for change.

### *3.3.2 Government as a learning facilitator*

Kim (1997) and others suggest three ways in which to think about the government's involvement: market mechanism, technology and time. The first, the market mechanism, deals with the demand and supply side of technology development. ***Although STI policy is often thought of more narrowly as a manifestation of the supply side, in fact, it is a critical player in demand side policies (more traditionally thought of as industrial policy, broadly speaking) fashioned by technological capability. (Kim, 1997, Westphal et al, 1985).***

Even if indigenous capabilities exist, they may remain un-commercialised. Those who envision and design the products and processes leading to innovation must remain connected to the task of commercialisation. It is often insufficient for inventors to hand over their findings to the private sector because the proof of concept itself is not easily transferred, and neither can those commercialising an innovation stay aloof from S&T research personnel once past the prototyping stage. The web of capabilities stays meshed and effective "systems" of innovation use a variety of skills from many sources at every stage. No one component stays isolated, seeking either appropriate supply or demand of inputs. Thus, STI policies become a core of the industrial, agricultural and services policies and create explicit links between market and non-market institutions, for example linking universities, state R&D laboratories, to unions, to community development organizations and to firms. Technology licensing offices may be one form of link between universities and firms, while agricultural extension services may do the same for farmers and seed or animal vaccine firms. The extension approach has been successfully applied in advanced countries to both the agricultural and the manufacturing sectors, a path that should be encouraged in underdeveloped countries. However, the successes and failures, particularly in agriculture and industry, cannot be

left undocumented. ***These “good” learning practices must be institutionalised into structured relationships between market and non-market organizations.***

The second aspect of government facilitation of learning deals with how it can create technology flows. These may be transfer of foreign technologies, diffusion of foreign technologies domestically as well as indigenous R&D efforts to innovate. While industrial policy usually covers these, STI policy often does not, leaving critical elements of acquisition, absorption and generation of technologies untouched and with no immediate link to the marketplace. In particular, those countries where STI policies directly form the basis for industrial and agricultural policies are at a greater advantage in terms of rapidly changing external economic conditions, or where the technological frontiers of the sector are moving outward rapidly. This is particularly true of advances in the medical sciences and computer systems.

***In essence, the role of the government in all its policies must be to enhance learning through strengthening other learning institutions such as schools, universities, government research organizations, firms and community-level technology diffusion initiatives.*** The development equivalent of the “triple helix” with a mix of firms, universities and the government, can play a significant role. However, community development organizations, which have been so important in environmental, primary health and agricultural realms, are important sources of innovation and diffusion, but also the articulation of future directions of governmental STI policies. Particularly important tools in STI policies for development are Government Technology Procurement (GTP). A multitude of countries have created and nurtured entire new industries or lagging old ones on this basis. In so doing, there have been many examples of gradual technological capability being built and of firms becoming competitive globally over time.

### *3.3.3 Enterprises as the locus of learning*

Even the most state-friendly explanations of economic development in the academic, empirical and policy literature acknowledge that while the government acts as a facilitator of institutionalizing knowledge acquisition/learning, the locus of that learning rests in enterprises-public or private. The structure of industrial organization and the nature of the production process itself, provide returns to scale of varying amounts based on input factors of skilled labour, robust management practices, other factors of production. The returns to deliberate investments that build innovative capacity show varying returns based on resource-base, institutional environment, among others.

Enterprises, particularly those involved in manufacturing, show great promise as centres of upgrading technology and organizational practices for developing countries. In addition, those enterprises that develop capabilities in design, R&D and product development, also establish themselves along a global value chain that allows for more opportunities for increased profit margins through innovation and product

differentiation. Yet, manufacturing remains a core skill important to long-term enterprise learning. Historically, "industry has long been the main source, user and diffuser of technical progress and associated skills and attitudes...In this world the manufacturing industry is not just an ingredient of development-it is the essential ingredient" (UNIDO, 2002-2003). Both the fact that manufacturing can experiment with endless permutations of inputs in the production process as well as the fact that it can benefit from the increasing returns to scale of many industrial technologies, gives manufacturing a special place in the long road of economic development.

Furthermore, it is also a driver of innovation because relative to formal R&D processes, manufacturing actually affords a much greater opportunity for experimentation in engineering and production and also innovation on the procurement, quality and other management aspects of the organization. Furthermore, enterprises with manufacturing capability have been historically critically important not only for creating the new products, but also for diffusing new processes, organizational practices and learning opportunities for the labour force. In turn, enterprises act as a locus for spreading innovation outwards into the agricultural and service sectors.

At the outset, the scope of interest for enterprise is to master imported technologies and to gradually improve upon them in ways that benefit local production. This in itself, although called "imitation", is not an entirely straightforward process of replication. Moreover: "An imitator working with an extremely sparse set of clues about details of the imitator's performance might as well adopt the more prestigious title of 'innovator', since most of the problem is really being solved independently. However, the knowledge that a problem has a solution does provide an incentive for persistence in efforts that might otherwise be abandoned" (Nelson and Winter, 1982: 124).

Perhaps most important, from an institutional and learning standpoint, is the historical role played by manufacturing enterprises in spearheading institutional change, particularly financial and legal, to support production processes worldwide. The extent to which these national institutions conform or diverge from global practice or those from first-mover countries, also defines the extent of convergence of learning speeds and economic development across countries.

This is not to make the case that we need homogeneity of institutions—in fact, evidence shows the opposite. To the extent that these national institutions are compatible with or open to other extra-national institutional changes, such as regulatory changes or trading rules, the more likely it is that national governments and domestic enterprises can make decisions that adapt local conditions quickly to the external economic and geo-political climate. The modernizing environment that was created by governments and firms alike in East Asia, by exposure to severe competition in export-oriented markets and by disciplinary measures hoisted on corporations by the governments of these countries, accelerated the investments made and the type of learning that took place across manufacturing enterprises.

### *3.3.4 Technological convergence and learning*

A major hurdle preventing the commitment of the S.E.T community to sustainable development is the preoccupation with maintaining and strengthening their own disciplinary turf when achieving MDGs requires cross-disciplinary and holistic approach. Science and technology know-how is not created within a single office or laboratory. An active process of sharing insights, problems, issues, experimental approaches, and outcomes creates knowledge. This occurs among people who have common interests, but they are not necessarily people within the same field of science or technology.

In fact, increasingly, the most interesting findings are emerging from the nexus of two or more fields of science. As STI institutions are created, nurtured, and encouraged in developing countries, it is important to tie their missions to specific problems and to enable a rich cross-sectoral exchange of knowledge to occur. Care should be taken not to create a “physics center” that is physically distant from the chemistry laboratory. The same is true for biology and materials sciences. The sciences and the technologies emerging from them grow by interaction. The social sciences are also an integral part of this process, creating a context in which to understand the source, modes of creation and dissemination and impact of S&T.

Thus, adjusting to the convergence across many areas of science means encouraging organization that enables the flows of information across and among them. This can be done using ICT, as well as by pointing out the success stories of universities and research institutions that have “de-institutionalized” their departments and encouraged cross-sectoral research. A specific way to adjust convergence across STI is to develop a particular style and method of technology assessment like the one performed by NOTA, the Netherlands Office of Technology Assessment, where social and economic goals in need of innovation are translated into R&D programs.

The biggest obstacle to cross-sectoral learning is the exaggerated pattern of narrow specialization that nowadays characterizes the search and application of knowledge. Encouraging, in all the possible range of stimuli and rewards, the organization of the research efforts by problems and not by disciplines, both in the North and the South, is a good way of fostering cross-sectoral learning. The problem is that researchers usually do not know how their knowledge can be used for addressing developmental problems; it is thus the responsibility of policy makers to devise strategies to help them find out how best they can contribute to development. One way to do this is to use a range of skills at their disposal and all combinations of inter-connected learning institutions to achieve the practical solutions of problems that can benefit the larger population.



## **4. GLOBAL FRAMEWORK OF ACTION**

The aim of this section is to outline elements of a global framework for promoting the application of science and technology to meeting the MDGs. It focuses on institutional innovations while at the same time providing a basis against which to identify enabling needs such as additional financial resources needed to operate at a scale that makes a difference. The framework for action focuses on five key areas: (a) improving the policy environment; (b) investing in human capacity; (c) promoting entrepreneurial activities; (d) investing in research and development; and (e) looking ahead through forecasting activities.

### **4.1 Improving the policy environment**

As noted above, government policies play an important role in creating a suitable environment for the application of science and technology to development. More specifically, government policies towards science and technology have a critical role to play in economic transformation. One of the key areas requiring policy adjustment in most developing countries is the way governments receive advice on issues related to the role of science and technology in development. There is a need for S&T advice to reach policymakers. The first necessary step is to provide the institutional framework and commit to support such framework. Amongst the most successful institutions are the Office of Science Advisor to top political leaders at the president or prime minister level and national scientific and engineering academies.

#### *4.1.1 Strengthening science advisory mechanisms*

Science and technology pervades all ministries and agencies of governments at international, regional and national levels. The dispersal of authority and implementation over multiple agencies often leads to confusion and duplication. The head of government gets conflicting advice. The science advisor offers advice that is scientifically accurate and relevant. No single individual science advisor can be expected to advise on a range of complex STI issues. A range of expert advisors must support the advisor. The most successful institution in this respect is academy of sciences and academy of engineering.

In Malaysia, for example, there is a tacit understanding that the President of the Academy of Sciences is the Science Advisor to the Prime Minister. The Malaysian government is following the examples of China and the State of Victoria, Australia in setting up the Natural Science and Technology Resource Centre, putting all S.E.T. representational institutions, such as engineering or scientific bodies within the natural, social or medical sciences etc under one roof. One of the aims is to strengthen the linkages of the Science Advisor's office to a web of independent scientific advisory bodies, which have public credibility and political confidence as well.

The Royal Society of London on behalf of the Inter-Academy Panel (IAP) of 90 national scientific academies conducted a survey on science advice by academies to governments. There was unanimity that science advice to government is one of the most important functions of an academy.

Unfortunately S&T is considered a luxury and has low priority in many developing countries. Even in countries where science has some measure of government patronage the impact of the academy of sciences on policy is often limited. Governments in developing countries have to be convinced that science and technology and related institutions can catalyse development. They must establish and strengthen such institutions. This can only be done through success stories.

#### **Box 4.1: National science advice: the case of Malaysia**

The Academy of Sciences, Malaysia (ASM) has been assisting the office of the Science Advisor to the Prime Minister that has instituted a series of far-reaching innovations to the structure of science advice to Government at the very top, including establishing institutions in his office for technology prospecting and matching and for venture capital. A fundamental feature of the ASM model was that a decision was made early on that the Academy should serve first and foremost national development objectives. It not only integrates the national science and engineering experts but also drivers of S.E.T. ASM has sustaining financial well-being by receiving a launching grant from government that has underwritten its annual operating and maintenance cost by investment income. This has enabled ASM to have a competent full time staff. Without financial stability and competent full time staff, no academy can function well. This ASM financial principle has served as a model for existing and new academies in Africa. Nigeria and South Africa has adopted the ASM financial model, whilst Zimbabwe and Tunisia intend to integrate scientists and engineers in their proposed academies. Another important element of the success of ASM is its vigorous cultivation of international S.E.T linkages, through regional and international organizations such as the Inter-Academy Council, Inter-Academy Panel, International Council for Science, Third World Academy of Sciences, ASEAN Council of Academies of Science and Engineering and the Science Council of Asia. This has enabled ASM to freely tap into the vast pool of international S.E.T knowledge, experience and expertise. ASM is much less successful in providing STI advice to industry. A particular characteristic of developing countries is the isolation of S&T academic organizations from the industrial community. The contacts are minimal and crossover of personnel from one to the other is limited. The forms of certification and validation of merit are entirely different. There is a need to construct means by which the applied and engineering sciences are brought closer to academia. One way to do this is to encourage S&T academies and associations to take on more functional activities such as training and certification of professionals and para-professionals working in industry. Member institutions of the World Federation of Engineering Organisations (WFEO) are doing this.

Source:

The IAP is committed to establishing and strengthening academies in developing countries. In 2002, IAP conducted a workshop for S&T ministers and leaders of

academies and prospective academies in African countries. In 2003, a similar workshop will be conducted for Islamic countries. The UN and donors should treat as a priority to support the IAP initiative for the creation and enhancement of STI advisory capacity in developing countries. They should also facilitate movement of qualified STI experts to be seconded into advisory capacities and to policy positions in these countries.

#### *4.1.2 Training decision-makers in science and technology policy*

The successful implementation of the STI policy requires the cooperation of the civil service. In the developing countries, a large number of top civil servants hail from non S&T disciplines. They are in a position intentionally or unintentionally to subvert the political will. It is most important that they are trained in technology management. The Commonwealth Partnership for Technology Management has been successful in training civil servants from African countries in this regard.

Another example is China where for the last 5-6 years, government policy has been to invite the highest calibre scientists from a variety of disciplines to make presentations regularly to the highest-level central government officials, including the Prime Minister and President. This event takes place about 4-5 times a year and is given high priority. Perhaps the most important element in propelling STI in China is the fact that all top political leaders are engineers and most political leaders and administrative officials at national, provincial, and city levels are S.E.T. professionals. Another example worth further investigation in the context of technology management is Singapore where all top civil servants have their first university degree in engineering.

#### *4.1.3 Building science and technology capacity among negotiators*

A different initiative comes from UNCTAD's Science and Technology Initiative which aims to equip key diplomats from developing countries with the ability to address science and technology issues related to trade, especially intellectual property, biodiversity, energy and climate negotiations and other such technically complex issues. The aim of the program is to have collective learning occur from examples across the globe, while allowing diplomats to represent their countries well through the analysis of complex issues. The WTO priority in capacity building is training of trade negotiators from developing countries, which should include science and technology issues.

### *4.2 Building human capabilities*

#### *4.2.1 Education for economic growth*

The one common element to the East Asian success stories is a high level of commitment to basic education and homogeneity within the countries. On the other hand, in much of Latin America and South Asia, an elite structure exists, with 15% or less of eligible students enrolled and in several Latin American countries, a "mass

structure" exists, that is between 15% and 35% of enrolment. This is a severe problem in itself, and more so if compared with the rate of enrolment of developed countries, on average above 50%.

Korea's commitment towards higher education shows that spectacular results can be achieved in a few decades. However, the growth of higher education must be accompanied by the growth of opportunities for graduates to apply the acquired capabilities, a lesson also provided by Korea. The strategy to achieve the first goal is rather straightforward: to devote resources or get complementary resources from international cooperation, to help more young people to go into higher education, paying special attention to the barriers that appear at secondary education. The second goal is to give incentives to private enterprises, particularly small and medium ones, to hire young university graduates, a strategy that helps to start a virtuous circle of technological upgrading.

In many developing countries it has been reported a growing phenomenon of "garage universities", granting diplomas without accredited quality, implying a waste of time and money for young people and their families, particularly the less well-off. Creating an Accreditation Agency to back serious higher education initiatives and to eliminate the fake ones is a feasible strategy to correct this problem.

#### **Box 4.2 Primary education and the Internet**

The mostly widely adopted primary science education program that is being promoted by IAP and ICSU (the International Council for Science) is the La Main a la pate (LAMAP) program of the French Academy of Sciences. The LAMAP methodology is hands-on and discovery-based. The French government has now adopted this methodology. Morocco, Senegal, Egypt, Colombia, Brazil, Hungary, China, Vietnam (and soon Malaysia) are implementing LAMAP. LAMAP has the most imaginative use of ICT and the Internet. It has a well designed and well used website. It is now the best resource for French primary school teachers. Apart from pedagogical resources and references, it is an active teachers forum. The website has a parallel forum of scientists and engineers to whom teachers can refer any problems. Scientists and university science students act as advisors to teachers in class. However, they are not allowed to interact directly with the students so as not to undermine the authority of the teacher and her rapport with her class. The support of advisors is a great help to the teacher. Similarly, in Germany, there is a junior civil service for youth with at least secondary education to help primary school children to strengthen their learning ability by devoting time to help them master the concepts given in class.

Source:

Primary education is overall important in developing countries. Besides the problem of coverage, there is a problem of quality, stemming from overcrowded classes and scarce cultural capital of pupils. To reinforce quality is difficult counting on the effort of teachers only. A possible strategy, inspired by practices implemented in some advanced countries, like Germany, is to raise a civil service for young people with at least

secondary schooling, to help children in school age to strengthen their learning abilities, particularly by devoting time to help them to master the concepts given in class. This sort of “collective solidarity” is specially suited to rural areas.

**Box: 4.3: The Colombo Plan: an example for Africa**

At the Commonwealth Conference on Foreign Affairs held in Colombo in January 1950, convened to exchange views on the needs of the countries of Asia, a Consultative Committee was established to survey needs, assess the resources available and required, focus world attention on the problems involved, and provide a framework within which international cooperation efforts could be promoted to assist the countries of the area to raise their living standards. The Plan embodies the concept of a collective intergovernmental effort toward the economic and social development of member countries in the Asia-Pacific region. The Plan encourages developing member countries to become donors themselves and participate in economic and technical cooperation among developing countries. The primary focus of all Colombo Plan activities was human resources development in the Asia-Pacific region. The Colombo Plan from the 1950s to the 1970s had the most successful human resource capacity building programme for South East Asia. Donor countries offered scholarships and fellowships to developing countries in altruistic spirit that was prevalent after Second World War. Although the program was within the Colombo Plan framework, it was essentially a collection of bilateral programs between specific donor and recipient countries. It was devoid of multilateral bureaucracy and politics. Program implementation was very focused to the needs of the recipient and the matching capabilities of the donor. Without doubt nations such as Malaysia, Singapore, Thailand, Indonesia and the Philippines etc were greatly helped by the technological and professional manpower trained under the Colombo Plan. It contributed significantly to the stable administrative transition from colonial rule in South-East Asia. It also had very important impact on donor countries, especially Australia. The presence of Colombo Plan students from Asia gradually triggered a flow of students from South-East Asia to Australia. The Colombo Plan Scholarship and Fellowship Program for South-East Asia virtually came to an end in the late Seventies before Africa assumed important on the world stage. Perhaps that was the reason why the program was not extended to the Commonwealth countries in Africa. The Colombo Plan Scholarship and Fellowship Program are worthy of further examination as a model for African technological and professional manpower development.

Source:

Although the MDGs are limited to efforts in primary education, the importance of science education at secondary and tertiary levels in the building up of an innovating society cannot be over-emphasised. Developing countries that have been able to show good economic growth have invested heavily in education, e.g. Tunisia that spends 30% of its budget on education. Developing countries should be encouraged to adopt curricula, which ensure that all students completing secondary education in any field would have been exposed to at least one area of science at secondary level. They should also be encouraged to invest in science education at secondary and tertiary levels in order to maximise output of scientists, engineers and technologists. The human resource base would then promote the utilization of STI in the country's development process.

Even if the country's absorptive capacity for scientists and engineers is limited due to its low stage of development, the human resources will not only be an attraction to foreign firms interested in investing in science and technology in the developing country but also encourage the movement of migrant workers who could contribute to the economy through inward remittances.

Furthermore, as seen in many countries, migrant workers contribute to the formation of SMEs though investment back home often utilizing technology learnt abroad and are involved in the establishment in their home countries of joint enterprises with firms in developed countries.

#### *4.2.2 Engineers in the global economy*

There is a disturbing global trend that enrolment in engineering courses in universities and institutions of higher learning is declining. These courses have also persistently remained unattractive to females that constitute half of the world population. This has been particularly evident in developed countries with the related phenomenon of closure of engineering departments in universities and institutions of higher learning. With regard to enrolment, the situation in science courses is not any better.

While developed countries have always had the alternative of recruiting engineers and scientists from developing countries, the same does not hold for the latter which desperately need the skilled engineering personnel at home. Developing countries suffer on three counts. First, they do not produce enough engineers and scientists for their own requirement as their engineering and scientific education and training infrastructure is inadequate. Second, they expend scarce hard foreign currency in sending their students for expensive engineering and science courses in developed countries. Third, there is the constant brain drain of engineers and scientists, usually the best and the brightest, to developed countries. Ironically, developing countries are putting scarce education and training resources that are benefiting the developed world.

One of the most hotly debated issues is the so-called brain drain. Admittedly, the home country's loss of skills—and, thus, educational investment—needs to be set against the experience gained abroad which may be available for use upon return. Temporary labour movements also present an advantage over (permanent) migration with respect to remittances. The magnitudes involved indicate potentially significant effects for such recipient countries as India, Mexico and Portugal.

For example, the remittances received by India in 1996, US\$ 7.6 billion, were almost three times as high as net direct investment inflows in the same year. In terms of foreign currency earnings, they came close to the contribution of the country's entire textiles and clothing industry (US\$ 8.6 billion) Taiwan set the trend for inviting expatriates home to participate in key R&D projects for national development.

### **4.3 Promoting entrepreneurial activities**

#### *4.3.1 Technology and international trade*

Until recently, the trading system, dominated by the agenda of the WTO, has addressed development only in piecemeal fashion. Debates on trade at the WTO have been conducted with little reference to a broader vision for how trade fits into development. TRIPS have taken centre stage. For instance, patent law changes have occupied much of the time of the WTO and created inordinate pressures on developing countries to harmonize their systems with those of the advanced industrialised countries. However, there has been relatively little appreciation for the time needed for institutional reform, even learning from the histories of now industrialised countries. A second important area of neglect is the area of TRIMS, with important implications for learning supports for enterprises and timelines for institutional reform.

In the most recent WTO Ministerial meeting (Doha, 2001), members recognized that there are links between trade and technological development, and that these links need to be better understood.<sup>8</sup> WTO also agreed to put development at the heart of the WTO Work Program. This agreement, together with the establishment of the Working Group on Trade and Transfer of Technology, has opened a window of opportunity to make the multilateral trading system more STI-development friendly. This will be very difficult. Interests against it are strong and expectations of significant change are low. But the rewards are worth the effort. An activity for this Task Force, perhaps in cooperation with the Trade Task Force, should be to support the work of this Group, by providing persuasive arguments and cases showing that everyone will benefit from a more STI-development friendly WTO. TRIMs, TRIPs, SPS rules and other factors that impact on trade and STI development should be examined.

#### *4.3.2 Incentives for enterprise development*

There are a range of incentive structures that can be used as a means for creating and growing enterprises, from taxation regimes and market based instruments to consumption policies and drivers within the national system of innovation. The clearer the development goals and the national agenda for development, the more easily associated regulatory and taxation incentives can be structured to act in the same direction. For example, taxation can be used for development, with Environmental Taxation Reform (ETR) shifting taxes away from environmentally and socially sound practices and placing them on polluting and environmentally damaging practices, thus

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<sup>8</sup> They agreed to set up a Working Group on Trade and Transfer of Technology to examine these links and make recommendations on how to accelerate the technology flows to developing countries to the next Ministerial meeting, to take place in Cancún in September 2003. The Working Group has met twice this year.

providing incentives for the community and business to pursue a sustainable future, while at the same time, developing competitive technologies close to world frontier.

Innovations in science and technology are mostly driven by private enterprises. Small and Medium Enterprises (SME) in developed countries have often been or are still the ones developing innovative and cutting edge technologies. In developing countries, SMEs growing from family owned and backyard repair enterprises have often been the foundation of industrialization. However, investments and incentives to grow SMEs have been minimal and often non-existent in most developing countries. Up till now, the focus of governments and foreign investment in developing nations has been on large infrastructure and industrial projects.

Specifically, incentives could be given for the: (a) establishment and encouragement of regional or national road-shows, technology days, trade shows, advertising, workshops, and online discussions; (b) motivation and encouragement of graduate students to consider entrepreneurship as a valid means of livelihood through creation, extension, and innovation of new and existing technology; (c) means of providing incentives for similar corporations in developed nations to partner and subcontract with companies in developing nations; and (d) establishment of private-public partnerships to invest in new technologies. While SMEs may benefit from these measures, they also provide broader impetus to all firms, while creating an institutional environment that encourages entrepreneurship, rewards innovation and fosters start-ups and sustains existing firms with injections of capital.

Each country's technological trajectory is unique, based on historical choice and circumstance and different institutional form. It is difficult to create comparisons that are useful. Nevertheless, considerable effort by a variety of researchers and policy makers has gone into the process of making comparative indicators robust. One such recent exercise has resulted in UNIDO's benchmarking industrial performance and its determinants for 87 countries between 1985 and 1998, where, for example, R&D financed by productive enterprises rather than total R&D is used as one indicator of industrial success. This benchmarking comparison is useful not only for countries to compare themselves to others, but in the longer-term interest of building learning institutions, it creates incentive for requiring enterprises, universities and governments to report and collect such data.

For instance, in 2000 and 2001, three countries, Australia, Canada and the United States have published national surveys of research commercialisation with comparable indices. This survey intends to give a snapshot of the innovative capability of a country allowing it to be benchmarked internationally. The information contained in the survey is aimed to give a measure of the commercial outputs being generated from research and includes metrics such as start-up companies, patents awarded and licensing agreements and income.



### *4.3.3 Foreign direct investment*

The global rules for FDI have changed, as have the modes in which they are most useful. Global production systems have changed the ways in which investments flow and how they can be made to invest in certain parts of the world for long-term growth instead of rapid flight to new, cheaper locales. FDI must be used as a vehicle for carrying tacit knowledge as well as assisting enterprises in learning where the world technological frontiers are. For example, In Taiwan's electronics and computer industries, FDI exposed workers to new organizational techniques; required domestic enterprises to comply with minimum international quality standards; and contributed to the development of local suppliers and supplier networks.<sup>9</sup>

In the case of China, which has emulated many of the successful practices of Taiwan, FDI by MNCs and other technology transfer modes such as hardware sales, licensing agreements, JVs, and wholly owned subsidiaries are highlighted as playing an important role in China's innovation system. One important impediment in the system is that the Chinese focused more on embodied and codified technology rather than intangible assets that could facilitate the transfer of tacit knowledge.<sup>10</sup>

Under the right conditions, foreign companies can contribute to local industrial development through FDI by providing capital, markets, technological and business skills, and by increasing the local content of their products through subcontracts with local SMEs. As such, it should be promoted. It is undoubtedly the case that countries with robust infrastructure, a highly trained workforce or large domestic markets, are better able to negotiate to extract maximum value from foreign companies, particularly MNCs. but some actions are also available to countries with different starting points. Developing country governments may promote FDI in STI for development through national Investment Promotion Agencies (IPAs). General guidelines could be developed and disseminated through the World Association of Investment Promotion Agencies (WAIPA), which has 140 member IPAs. These would serve as a basis for national discussion and adaptation. The process of FDI promotion could begin by identifying foreign companies already investing in the country/region. The export profile of the country should be examined to identify potentials. Existing investors (domestic and foreign) could be approached to find out what they need to invest more, and to increase local added value.

Successful experiences show that a strategy for promoting FDI that will contribute to development should target specific sectors and activities. For less developed countries, a good target is commodity diversification. Indeed, most low-income countries depend

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<sup>9</sup> Ernst, Dieter, 2000. "Inter-Organizational Knowledge Outsourcing: What Permits Small Taiwanese Firms to Compete in the Computer Industry?" *Asia Pacific Journal of Management*, Vol. 17, pp. 223-255

<sup>10</sup> (2) Liu, Xielin and White, Steven. 2001. "Comparing Innovation Systems: A Framework and Application to China's Transitional Context" *Research Policy*, 30: 1091-1114.

on one to three commodities for their exports, and that dependence has plunged them deeper into poverty. The goal is to diversify exports by adding value to the commodity base. International attention to commodities is rising. For instance, NGOs such as Oxfam are pushing donor countries to address commodity over-dependence. Donor countries agreed in major Summits in Monterrey and Johannesburg this year to address commodity issues; more recently, governments requested the General Assembly and the UN agreed by consensus at the end of the current session to establish a group of eminent persons to recommend actions on commodities to the General Assembly in 2003. Prospects for increased resources from donors and others for commodity-related activities are improving.

Requirements for FDI in LDCs and low-income countries will vary according to commodity, location and stage of development. Others, such as economic and foreign exchange stability, foreign trade conditions for market access and temporary protection from competition to develop new activities, technological and business skills and protection of IPRs are the result of national economic and social policies, often imposed by international rules and conditions.

It should be noted that developing countries today do not have the policy options available to other countries that were fighting poverty before them, because of conditionalities for funding from the IMF and the World Bank, and trade rules from the WTO and other free trade agreements. These rules and conditionalities need to be relaxed. A task for this project could be to open policy space, and to provide policy and strategy options to developing countries. These could be channelled (with creative persuasion) through (a) the Poverty Reduction Strategy Papers (PRSPs) and (b) UN Development Assistance Frameworks (UNDAFs).<sup>11</sup>

#### *4.3.4 Protecting intellectual property rights*

To encourage true innovation, individuals and corporation will need to feel that their hard earned research is protected and in cases where there has been a violation of their intellectual property that adequate compensation is provided. However, most countries appear to have developed over time without these benefits being structured across the economy in any clear way. Indeed, institutional development of patent regimes occurred usually after the country's firms achieved a significant level of innovation capability and then desired to protect their investments.

Thus less developed countries may need to work together to think of how to: (a) create an avenue for emulation of products and technology without infringement of the

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<sup>11</sup> (a) PRSPs are a new instrument designed by the IMF and World Bank, mandatory for low-income countries to gain access to debt relief and concessional loans. Bilateral donors are expected to allocate development cooperation resources based increasingly on PRSPs. Developing countries draft the PRSPs with assistance from the UN and other development agencies. (b) UNDAFs are used to coordinate the work of UN agencies in the field. Inputs on the importance of STI development, including the role of FDI, could be included in the UNDAF guidelines; a training module could also be designed for local and international professionals engaged in these exercises.

intellectual property; (b) use regional and zonal patent right protection; (c) create a loyalty system to facilitate revenue sharing between the patent owner and the local user where the local can only use such patent within an approved zone; and establish a tiered system of protections that is dependent on the GDP per capita and where the patent filing comes from.

For example, one scenario could be that the highest level of protection (provisions of TRIPS, level A) must be accepted by developing countries with say a GDP of more than \$ 5000 or perhaps an export criterion, a lesser level B for those with GDP \$ 1000-5000 and a still lower level C for those with GDP less than \$1000. The C level will meet most of the demands made by the developing countries, as amendments to TRIPS while the B level will afford intermediate levels of protection. Applications for intellectual property rights must be made at the highest level taking into consideration the countries of residence, citizenship or incorporation of the inventors or assignees.<sup>12</sup>

Developing countries at low economic levels could for instance be permitted to allow process patents and use these patented methods to make drugs for their own market and for markets in other countries offering C level protection but they would not be able to compete in markets affording A level protection. Successful developing countries with C level protection may become industrialized and in time meet the criteria to reach the intermediate level and they would then have to amend their laws to afford B level IPR. These might facilitate the eventual adoption of patent regimes desirable to both advanced industrialized and developing countries, while still allowing the latter to frame their own.

#### *4.3.5 Industrial extension services*

Knowledge extension can be applied to help meet the MDGs using science, engineering and technology in many ways. This is a case where ICT could be effectively applied to help. The person with the knowledge and the person with the problem could be effectively matched using ICT, and they would not need to be co-located in time or place in order to discuss how to solve a specific problem. Establishing a virtual centre, one that ties into the many existing extension and engineering centres around the world, is an exciting prospect that could bring knowledge to places that badly need it. Training extension officers in pilot projects has been attempted in some cases, and an examination of how, where, why and when this works, and accumulating the best practices into freely accessible data bases would be another way to use ICT to effectively and efficiently diffuse technology and encourage its appropriate adoption in developing countries.

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<sup>12</sup> Thus if one of the applicants or the assignee is from a developed country, the initial application must be made in a country with A level protection. If all the applicants are from a least developed country, they can apply for protection in their own country where the laws may provide C level of protection. However, if these applicants wish to extend their rights to cover a developed country, they would be able to obtain only C level protection for their invention even in the developed country which has provision for A level protection.

#### *4.3.6 Government procurement*

Government technology procurement (GTP) can be an important tool in low-income countries, characterized by weak productive sectors and a weak technological demand. While there is an ideological contesting of the role of public support for procurement -- and in fact WTO members have agreed to look into public procurement in the context of trade liberalization—the fact remains that a multitude of countries have created and nurtured entire new industries or lagging old ones on this basis. In so doing, there have been many examples of gradual technological capability being built and of firms becoming competitive globally over time. The critical issues are less whether public procurement is needed and for what purpose, than when it ceases and how it assists firms in competing on their own.

For instance, in the drive to make nationally owned firms globally competitive, The Chinese government promotes domestic computer hardware firms through both direct and indirect support including favoured treatment in government procurement as well as access to technologies developed in state R&D institutions. The Indian government does the same with the pharmaceutical industry for public health's "essential" drugs and other sectors have seen such policies in the past at critical stages of their development.

The Nordic countries show fairly high success rate of public procurement in promoting industrial development, specifically telecommunications, and has been widely accepted by the general public and various important representative organisations.

Where GTP is currently used the most, and perhaps ideologically the least contested area for public procurement is in building public health infrastructure and access to medicine. This experience can be used to develop GTP with strict guidelines for the selection of local partners and in the evaluation of the products and services delivered. This is the only way to foster a real learning process. Equally important is to assure that participation is inclusive.

One way to do this is, for instance, not requiring extensive international experience as a condition in procurement specification, a condition most local firms will not be able to fulfil. In this regard, Government should support Green Procurement. Transition to environmentally cleaner technologies can be supported through green procurement policies.

#### *4.3.7 Capital markets for growth*

SMEs have flourished in most developed nations because of the critical role that the capital markets have played in creating that business, especially the role that the venture capitalist market has played. Venture capitalists (VC) do not just bring money to the table; they help groom these start-ups into multi-national institutions. Another advantage of bringing venture capital markets into developing nations may be to ensure

the sustainability of the companies they invest in. Studies have also shown that companies in developing nations rarely survive beyond the lifetime of the initial founder and owner. In other words, in developing nations, people tend to go to their graves with the knowledge, expertise and assets of the company. More than one person usually owns a VC funded company and the VC ensures that their investment is safe by always having a succession plan in place.

#### **Box 4.4: Fostering capital market growth**

A variety of methods can be used to promote the creation of capital markets. These include:

- Create sound monetary policies, reduce cost inhibitors, allow loans to be secured with intellectual property, and provide insurance and indemnity protection on loans to SMEs.
- Provide additional capital incentives for specific technologies. This could be for privately backed VCs and lending institutions to create specific policies for supporting SMEs engaged in developing technologies of particular interest. These could be differential rates of borrowing, access to domain experts or preferential access to new R&D from local or foreign government or university research institutions.
- Create a government funded venture type investment strategy. Capital markets do not automatically exist for all sectors or technologies. Indeed, part of the very process of development is the creation of such institutions to focus on stimulating interest in a particular type of technology that the government or public deem priority for development but for which private sector funding is not forthcoming.
- Help government initiated capital to become professionally managed. In India, for instance, government funds for R&D and SMEs exist, but the management of these funds often face difficulties with assessing new technologies due to lack of domain expertise, among others. The “graduation” of such traditional investors to more professional and technological management requires not only government support but ideally international learning exposure as well.
- Support micro finance. Such schemes are emerging as a key way to help poor entrepreneurs to help themselves. The technological components of such enterprises can be substantial, ranging from food processing to auto repair to solar energy or other initiatives. The idea came from Asia in the 1970s, when organisations such as the Grameen Bank in rural Bangladesh, SEWA and the Working Women’s Federation in India, began lending small sums of money to the landless poor. These evolved from other traditional patterns of savings such as rotating schemes. Almost everyone repaid the loans and the scheme was so successful that a few years later, it had over a million borrowers. Micro finance also provides an opportunity for very small firms to build links and scale at the same time to facilitate simple technology transfer and to even consider export opportunities.

Source:

Sustainable development type investment is also creating additional capital opportunities, with investment from superannuation and pension funds making up a large proportion of the trillions of dollars currently invested internationally. There are at least four stock market indexes that track ‘sustainable businesses’: the Domini 400 Social Index in the USA, the NPI Social Index in Britain, the Janizi Social Index in

Canada, and the Dow Jones Sustainability Group Index for international shares. Three of these indexes—the Domini 400, the NPI and the Dow Jones Sustainability Group—have all been around long enough to now have a track record which can be compared to the main markets. In each case they have all outperformed their sustainability neutral counterparts.

There are also a number of Market Based Instruments being developed which use trading mechanisms, auctions and price signals to change corporate behaviour. Rather than prescribing behaviour or technology use, MBIs give more flexibility in the sustainable use and management of natural resources, while providing market mechanisms for development. Many countries, from Poland to the Netherlands have created rolling funds to provide credit schemes to give companies additional incentives to do the right thing.

Thus far, these have been seen largely as a feature of developed economies, but they hold considerable potential for less developed countries as well. The government must take the lead in this effort, but with substantial inputs from both private sector and non-profit organisations as well.

#### **4.4 Investing in research and development**

##### *4.4.1 Enhancing scientific and technological capabilities*

A fundamental problem in this regard is that researchers in developing countries often suffer from a schizophrenic system of rewards. If they work on problems of interest to international science, they will probably be able to have a harvest of published production, however far these problems may be in relation to development. However, if they work on important problems for their locale, they risk not being able to publish their findings in mainstream journals or being invited into intellectual circles of international standing and repute. One important way to create incentives for research on development needs is, then, to rethink and “endogenize” the academic reward system. A faster way to create incentives is to organize calls for research proposals directed to solve developmental problems, particularly those that affect the poor. This does not mean to concentrate exclusively on “applied” research. After all, real-world problems do not come organized by type of research and more often than not, a variety of knowledge types is necessary to solve the very complex issues that affect deprived populations.

Another significant problem in developing countries is the absence of demand for value-added and more sophisticated technological activity. One of these technological activities could be R&D as the collective learning function of enterprises, i.e. their organisational path to assimilating and innovating new technologies. If this important function were left unattended, enterprises would then remain largely dependent on imported technologies that are not suitably adapted for local conditions. If demand for

future high-level technological activity is not transmitted to enterprises through appropriate policies, we run the risk of only stimulating current demand. One element of successful interventions in East Asia has been precisely this type of demand-side boost, which complements the market mechanism, to create incentives for enterprises to invest in R&D and raise levels of R&D spending significantly.

One effect of the biotech and pharmaceutical “revolution” is the impression that early-stage scientific R&D is at the core of innovation. But it is equally true that R&D at the manufacturing phase can be an equally important driver of innovation. The success stories of the past century have been those countries with significant investments in manufacturing sophistication. This in turn boosted the level of investments of foreign and domestic firms in the economy due to their confidence in the S.E.T infrastructure and skill base in the country.

Another problem for less developed countries is the relative isolation of their research institutes and laboratories. In particular, commercialization of R&D faces problems of scaling up from laboratory findings to industrial output. There is no easy solution for this but to create opportunities for R&D laboratories in the public domain to work with private industry. The reverse is also true. Many developing countries have technically qualified personnel in the non-government sectors.

Yet, the institution channels for participation in science policy formulation and implementation are rigid and there are few avenues for dedicated and qualified personnel within the country to be associated with large-scale, nationally important projects unless they are within the civil services. A first step would be to craft a system of secondment opportunities of experts who could work alongside bureaucrats and assist the development projects. These experts could be brought in from industry, other branches of government, universities or non-profit sectors.

Australia's Cooperative Research Centres (CRCs), bring together researchers from universities, CSIRO (Commonwealth Scientific and Industrial Research Organisation), and other government laboratories or public sector agencies, and private industry, in collaborative arrangements that support research and development and education activities that achieve real outcomes of national economic and social significance. The CRC is funded by government, university/research institution and industry with the mission to commercialise successfully their R&D endeavour within 5-7 years. CRCs are run as enterprises. The idea of the CRCs is that culture, ideas and commercialisation are at the core of building domestic S.E.T capability and the program recognises that the Government is the key facilitator for the innovation environment.

Getting government, university/research institution and industry together has not been without difficulties and failures. The encouraging feature is that all three parties are committed to carry on. There are 67 CRCs across Australia covering six industry sectors and the program addresses important weaknesses in Australia's national

innovation system, in particular the disincentives to collaboration, the lack of connection to users, the lack of critical mass of R&D facilities, lack of mobility of people between government research, academia and industry, and the challenges of effective international links for a country isolated from the international centres of research and innovation.<sup>13</sup>

China has put a different twist to the spin-off story.<sup>14</sup> Spin-offs exist in various forms and government support has been forthcoming to commercialise university research findings. Technologies developed in universities and research institutes are usually implemented in three ways. They are implemented in spin-off independent ventures, in licensed entities in a technology development zone that used to be internal institutes of research organizations, or in new ventures started by former research staff that are still supported by the organization.<sup>15</sup>

For instance, of the computer market leaders, Legend is affiliated with the Chinese Academy of Sciences (CAS), the leading government research institution. Founder Group is affiliated with Beijing University, and Great Wall is a spin-off of the now defunct Ministry of Electronics Industry. While each of these companies was restructured into joint-stock companies and listed in either the Hong Kong or local stock exchange, each of them is still controlled by a holding company that is owned by the affiliated government organization.

Another example comes from Finland where the Centres of Expertise program is a nationally driven and regionally supported initiative that geographically disperses across a small country a concentration of experts in various fields. These researchers work in Centres that interact locally with universities and industry. In addition, the Centres get dedicated funding and also compete for resources. Well-acclaimed and peer reviewed S&T personnel are nominated to positions and researchers may also apply directly. The Centres also act to create economies of scale in a small country that must consolidate its resources.

The subjects to be researched and developed by consortium members vary, including products, process technologies, and even technical standards. In Taiwan, the role of FDI has declined relative to the development and popularity of international outsourcing arrangements such as international subcontracting, various forms of original equipment manufacturing contracts that involve higher value-added services such as product customisation and design. Cross-border networks include joint ventures, licensing arrangements, international supplier networks, original equipment manufacturers (OEM), original design and manufacturers (ODM), and international strategic alliances.

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<sup>13</sup> Mercer & Stocker, 1997, A Review of Greater Commercialisation and Self Funding in the Cooperative Research Centres Programme, Department of Industry Science and Resources, Canberra, Australia.

<sup>14</sup> Kraemer, Kenneth. L. and Dedrick, Jason. 2002. "Enter the Dragon: China's Computer Industry". *IEEE*. pp. 28-36.

<sup>15</sup> Liu, Xiulin and White, Steven. 2001. "Comparing Innovation Systems: A Framework and Application to China's Transitional Context" *Research Policy*, 30: 1091-1114.



Firm networks within Taiwan include subcontracting networks (SNs) and cooperative networks (CNs), global logistics networks, and R&D consortia. Cross-border firm networks are the channels through which Taiwanese firms learn and assimilate technology from foreign multinationals and overseas buyers.<sup>16</sup> Industry associations such as Taiwan Electrical and Electronics Manufacturers' Association (TEEMA) were involved in identifying interested enterprises to join R&D consortia and in performing administrative work for the consortia established.

#### **Box 4.5: Industrial spin-offs in Taiwan**

In Taiwan, there are examples of private enterprises in the ICT industry spinning off from government-sponsored research institutions to facilitate technology transfer and diffusion. United Microelectronics Corporation (UMC) was the first of a series of 'spin-off' ventures from the government-funded Industrial and Technology Research Institute (ITRI) to establish private-sector semiconductor capability in Taiwan. Established in 1980, UMC was the first spin-off from the pilot fabrication operations of Electronics Research Service Organization (ERSO), one of ITRI's laboratories. One of the world's first silicon foundries, Taiwan Semiconductor Manufacturing Company (TSMC), was created by ITRI in 1986, as a joint venture of the Dutch multinational Philips, and a group of Taiwanese firms, with the support of the Taiwan Development Fund, thus creating a new breed of world class enterprises playing an important role in facilitating technology learning and transfer. In Taiwan, there is also an explicit strategy to blend private and public sources of knowledge with the view to commercialisation through group R&D efforts. For example, the Taiwan NewPC Consortium formed with the assistance of the Computer and Communication Research Laboratories (CCL) of ITRI, to assist SMEs in transferring technology from leading IT firms in the US to make PowerPC microprocessors and products using such chips. More than 30 R&D consortia have been formed in Taiwan since the 1980s to transfer technologies and develop electronics, opto-electronics and materials, as well as computing and communications products. Examples are laptop computers, HDTVs, videophones, laser faxes, broadband communications, digital switching devices, satellite receiving stations, and smart cards.

Source:

Another interesting example on how S&T policy for regional development was structured and implemented in a simple way comes from the Basque region in Spain. The Introducing Microelectronics in Industry (IMI) project, was developed in a twofold way. Its two-pronged strategy was ingenious. The first was to aim for "microelectronic literacy", aimed at the population at large: this part was accomplished through a widespread schooling system, both in principal cities and in the countryside, where different modules were offered, ranging from elementary notions to advanced levels of technical training. The second strategy was to prepare a directory of technically accredited local electronic firms, including information on each firm and some real-

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<sup>16</sup> Poon, Teresa Shuk-ching, 2002. "Taiwan NewPC Consortium: Pushing Toward Developing Critical Components and Formulating Industry Standards" in *Competition and Cooperation in Taiwan's Information Technology Industry: Inter-firm Networks and Industrial Upgrading*. Westport: Quorum Books. Chapter 6, pp. 143-168.

world examples of their solving-problems capabilities. This directory was made available to the whole industrial sector to foster user-producer relationships in the local space.

Moreover, if a project emerged from such relationships, the Basque Government, through the Society for the Promotion of Industrial Transformation, granted up to the 50% of the cost of implementing it. Taking inspiration from this example, it can be said that a good practice for STI policy is to foster user-producer relationships by providing information about local capabilities to solve problems and to have a fund specifically dedicated to help them to develop.

Besides partnering with industry, another choice that governments and universities have is to create incentives for researchers to commercialise their own ideas. The Indian Institute of Science (IISc) in Bangalore, India, is now experimenting with an array of commercialisation options to facilitate commercialisation of university-originating ideas. Specifically, for the first time, the institute has experimented with allowing faculty to hold simultaneous positions in firms, to negotiate patent licensing through the institute, and to benefit from stock options offered through firms. The learning curve is steep and the models of MIT and Stanford, for instance, offer only limited guidance.

Investing in long-term research capacity in the public sector is most successful when it is tied to specific missions. These can be local problems, such as health or environment, or local capabilities or resources, such as earthquake monitoring. A mission focus, particularly when it is tied to a threat (hunger, earthquakes), can help to generate and maintain critical political support when funding is needed to renew budgets or help disseminate knowledge to specific users. The challenge, however, is to sustain political support and public interest for more “normal” development problems, which have no short-term fixes.

Private sector capacity can be built in a number of ways, some of which are dependent upon the nature of the industry itself. However, in general, financial incentives to invest in research equipment or training can help to build long-term research capacity. Easing legal restrictions on cooperation among companies can help build networks for shared research. Changing intellectual property laws can help encourage firms to participate in international collaborations that may provide needed information and access to skills. Direct funding for a specific line of research, along with promises of procurement of final products, can also be excellent ways to promote long-term investments in private research capacity.

One way to explicitly work towards solving development problems while developing long-term capacity in both public (particularly academic) and private realms is highlighted by an example from South America. A few years ago, the Venezuelan National Science and Technology Council developed a new strategy to foster long-term research capacity related to development goals. It consisted of selecting a few big

complex problems and funding competitive proposals around them, encouraging interdisciplinary teams, including firms, to address different aspects of each issue. The selected problems included those associated with the oil industry, urban violence and fighting against a virus that attacked the cacao production. The importance of this initiative goes beyond the results obtained: it points to shifting the academic reward system away from pure “paper counting” to prizing the ability to work on problems related to the nation's wealth and people’s well being.

#### *4.4.2 Supporting under-funded research*

There are a variety of ways to channel resources towards pressing development problems that are currently under-funded. Bilateral donors could increase their official development assistance by 10% and use the additional funds for development. The HDR 2001 proposes such a framework. Good practices could be provided to donors as a source of ideas to develop effective bilateral development programs. An example of good practice is SAREC, a program of Sweden’s Development Cooperation Agency (SIDA). SAREC is active in many developing countries.

#### **Box 4.6: Funding research through cess**

One way to target sector-specific technological needs is to introduce an industry-wide cess. For example, cesses on rubber, palm oil and timber have been imposed by Malaysia to fund the Rubber Research Institute, the Palm Oil Research Institute and the Forestry Research Institute respectively. A cess on tea helps fund tea research and tea marketing in Sri Lanka. Hong Kong, Singapore and Malaysia have established Construction Industry Development Board (CIDB). The funding is from a compulsory cess on every construction contract. The revenue is used in capacity building and promotion of innovations in construction materials and techniques.

Apart from cess on export products, a cess on imports designed to mobilise funds for industrial development and STI is also logical, although it may face objection from WTO. In order to encourage stock markets that are largely speculative in developed and developing countries to contribute to sustainable development in developing countries, a cess of 0.05 or 0.1% of the turnover of stock markets could be imposed and used to establish a global fund for sustainable development.

Source:

In Cuba, for example, it has helped develop a very effective domestic health sector.<sup>17</sup> This strategy could develop guidelines for national government officials to identify sectors, projects and activities (at the local, national and regional levels); the guidelines could be based on this task force’s operational output. The recommendations could then serve as a basis for consultations between donor and recipient governments.

<sup>17</sup> (for further information please see <http://www.sida.se/Sida/jsp/Crosslink.jsp?d=396>).

Private companies already committed to being good corporate citizens for development could be further engaged. The first step would be to identify the companies and group them by sector/region where they operate, by, among others, reviewing membership lists of gatherings like the UN Global Compact and the US Council for International Business. Targeted messages could be developed for each group. A forum could be provided for discussion between companies, governments and others to identify specific areas of involvement. The UN Global Compact could be engaged to promote more actively public-private sector partnerships for development among its members worldwide.

Another instrument is cross subsidy. A cess is imposed in Malaysia on the turnover of corporative electricity generators to fund rural electrification and renewable energy development in Malaysia. In private sector housing developments in Malaysia, 30% of the housing units must be low cost that are subsidized by the selling prices of medium and high priced units. This has prevented the identification of income level with location in urban centers and has assisted in arresting the spread of slums.

#### *4.4.3 Forging international partnerships*

International partnerships also provide avenues for funding research in neglected fields. One example is in operation in Singapore. It is the Novartis Institute for Tropical Diseases (NITD) established by the Swiss pharmaceutical company, Novartis and the Singapore Economic Development Board (SEDB). The primary aim is to create increased access to drugs, initially for TB and dengue fever by making new drugs available to poor people in developing countries at the lowest possible price. This includes the possibility of differential pricing strategies (re-finance the research through higher prices in developed country markets) as well as additional partnerships for development, manufacturing (considering Singapore as a manufacturing location) and distribution of drugs. Novartis will patent novel compounds, but patents shall not interfere with the goal to make drugs affordable for the poor.

This represents a new business model for Novartis, and a commitment to social responsibility. Novartis's interest is to broaden their research base in infectious diseases as well as fulfil commitments to help find new treatments for diseases that are becoming an increasing public health challenge. This latter goal also fulfils the company's role as a Good Corporate Citizen through its commitment to the UN Global Compact. The commercial interests are also clear for the company: it strives to re-finance the institute's activities and make it economically sustainable—Novartis retains marketing rights for compounds that have a significant commercial potential in developed markets.

From the Singapore national interest, the SEDB desires strengthening the technology platform in Singapore, developing manpower capabilities, commercialising opportunities through rights to commercialise technologies and products arising from

NITD. It anticipates that such partnerships will have positive spin-off effects, potentially leading and contributing to the proliferation of local biomedical start-ups.

The above example should be replicated even though persuading multinational corporations like Novartis to base a research institute is not so easy in other developing countries. Countries that have the research environment (infrastructure, economic policies, institutional strength, etc) can influence the decisions of such firms to base their operations in their territories.

A mentoring scheme where a developed country institution or firm becoming involved in an S&T initiative with a more developed developing country could be persuaded to team up with a less developed developing country might be an answer. If the Novartis Institute for Tropical Diseases based in Singapore also involves a third country like say Bangladesh where there would be some S&T institutional and human resource capacity building through farming out of projects, movement of scientists, technology incubators, spin-offs the results. This would encourage Bangladesh Government to devote more resources to strengthening S&T institutions. Such third country involvement will not take place without a mentoring scheme being organized through an international agency, which could identify potential partners and promote their collaboration

## **4.5 Looking ahead**

### *4.5.1 Sharpening the focus*

Foresight or forecasting is a method of establishing priorities in science and technology funding and policy based on analysis of current trends and expectations of future developments. Foresight studies and exercises have been conducted in many countries since the 1960s for a number of reasons (i.e., defence planning, prioritisation, subsidization). Originally seen as simply a tool for identifying new technologies, foresight is now viewed as a tool to aid in understanding the full innovation system. The usefulness of this tool depends upon first identifying the key participants; delineating goals, especially the balance between desired process and product outcomes; defining how the foresight exercise would be used to stimulate innovation; and tying the foresight process into the national decision-making structure. In addition, a well-planned foresight process should consider issues of: governance and auspices; how the inherent uncertainty attending all innovative processes and future projection will be addressed, and perhaps, the means for evaluating the success of the foresight process as a whole.

In order to be a part of the world market for new technologies, enterprises need to be aware of the opportunities being presented by technological development. Sometimes called “leapfrogging,” the opportunity to enter a new market as new technology is introduced is potentially an excellent way for enterprises in developing countries to join

the global system. Foresight can occur within business associations or be led by government or university groups. Specifically, for “information harvesting”, for example, satellites and spatial information can provide significant new information, new or finely graded information of significance to less developed countries. Geographical Information Systems (GIS) can be used to map out settlements and ecological implications for various policies. For entry into new markets, some biotechnologies and computer technologies have provided opportunities for rapid ramp up and learning in some developing countries.

Technology prospecting can provide the tools for developing countries to keep abreast of new developments. One way would be to identify methods, sources, and assessment tools for understanding new sciences and technologies as they emerge and providing these to developing countries. Another would be establishing a global database of information on centres of excellence where very good, groundbreaking research is taking place. These can be the “places to watch” for countries, regions and enterprises interested in tapping into and developing new technologies. A third way would be to create public-private partnerships that track, transfer, and train developing country consortia in technology prospecting and the application of technology to business.

### *3.5.2 Broadening the vision*

Science and technology is applied to innovation within a social and economic context. S&T has no intrinsic moral or ethical value—the ethics emerge as knowledge and its application merges with culture. There may be cases where a local culture understands, but simply decides not to adopt a technology. In other cases, local knowledge can greatly enhance the effective application of knowledge. This process works best when stakeholders (citizens, knowledge workers, politicians) take part in the decision-making process.

Citizen councils have been used quite effectively in Europe. The mechanism of “consensus councils” has a long tradition of settling contentious matters in science and technology. In the late 1980s, for example, the Danish board of technology defined consensus councils as bodies of lay citizens that would be convened to consider the evidence on a particular science or technology issue, participate in public debate, and ultimately provide a consensus report of their findings and policy recommendations. The purpose of the process was not to dictate policy but instead to help the legislature understand where an educated population might stand on an issue before considering specific policies. This success led to the engagement of similar processes in the Netherlands, the United Kingdom, and France.

However, the councils would need to be identified, constituted, and convened at the local and regional levels and around specific issues (e.g., genetically modified foods) in order to be effective. In addition, the councils must have a real part to play in recommending policy changes that stick.

An especially interesting exercise is related to public opinion about science and technology. This type of public opinion polling has been performed in Europe and the USA and through some grass-roots people's organisations in India, showing people's hopes and fears related to S&T. In Uruguay, an exercise of this type has been done in the late nineties, showing that 57% of the population was in favour of doing R&D with the country's own budgetary resources, given their belief that this would enhance the country's development prospects. However, when asked about the relationships between S&T and dependency, the less educated answered that S&T deepened the country's dependency on external factors, while the best educated answered the exact opposite. One could interpret this to suggest that those with less formal education knew less about the country's indigenous capabilities in S&T, believing the solution of various developmental problems to have been exclusively foreign, while the best educated knew well the local achievements in solving-problems through R&D. From this interpretation one might suggest that an important effort at media level is required to present S&T not only as "world achievements" but also as local ones, using and benefiting from local skills and local learning institutions.

## SELECTED BIBLIOGRAPHY

- Amsden, Alice. 1989. *Asia's Next Giant: South Korea and Late Industrialization*, Oxford University Press, New York and London.
- Freeman, Chris, 1995: "The National System of Innovation" in historical perspective, *Cambridge Journal of Economics* 19: 5-24
- Rosenberg, Nathan and LE Birdzell, Jr. 1986. *How the West Grew Rich: The Economic Transformation of the Industrial World*, Basic Books, 1986.
- Lundvall, B.A. 1988 "Innovation as an Interactive Process: From User-producer interaction to the National System of Innovation", in Dosi G. *et al. Technical Change and Economic Theory*, (London: Pinter), pp. 349-369.
- Kim, Linsu. 1997. *Imitation to Innovation, The Dynamics of Korea's Technological Learning*, Harvard Business School Press, Boston, MA.
- Kim, Linsu and Richard R. Nelson. (Eds.) 2000. *Technology, Learning, and Innovation, Experiences of Newly Industrializing Economies*, Cambridge University Press, New York.
- Lall. 2000, "Technological Change and Industrialization in the Asian Newly Industrializing Economies: Achievements and Challenges", in Kim and Nelson (Eds.), *Technology, Learning, and Innovation, Experiences of Newly Industrializing Economies*, Cambridge University Press, New York.
- Nelson, Richard. 2000 "Different Perspectives on Technological Evolution", in J. Ziman (Ed.) *Technological Innovation as an Evolutionary Process*, Cambridge University Press, Cambridge.
- Pavitt, Keith. 2002. *Knowledge about knowledge since Nelson and Winter: a mixed record*, SPRU, Science and Technology Policy research Electronic Working Paper Series, Paper No. 83, University of Sussex, <http://www.sussex.ac.uk/spru>)
- Smith, Adrian. 2002. "Transforming technological Regimes for Sustainable Development: a role for Appropriate Technology niches?", Electronic Working paper Series, paper No. 86, Science and Technology Policy Research, University of Sussex, <http://www.sussex.sc.ul/spru/>)
- UNCTAD. 2002. *The Least Developed Countries Report 2002. Escaping the Poverty Trap*. United Nations Conference on Trade and Development, Geneva.
- UNDP. 2001. *Human Development Report 2001. Making Technologies Work for Human Development*, United Nations Development Program, New York.
- UNIDO. 2002. *Industrial Development Report 2002/2003. Competing through Innovation and Learning*, United Nations Industrial Development Organisation, Vienna.



Vandemoortele, Jan. 2002. “*Are the MDGs feasible?*” UNDP Bureau for Development Policy, New York, July).

World Bank. 2000. *Can Africa Claim the 21<sup>st</sup> Century?* World Bank, Washington D.C.

Westphal, Larry E., Linsu Kim and Carl J. Dahlman. 1985. “Reflections on the Republic of Korea’s Acquisition of Technological Capability”, in Nathan Rosenberg and Claudio Frischtak (Eds.) *International Transfer of Technology: Concepts, Measures and Comparisons*, Praeger Press, New York, pp. 165-221.