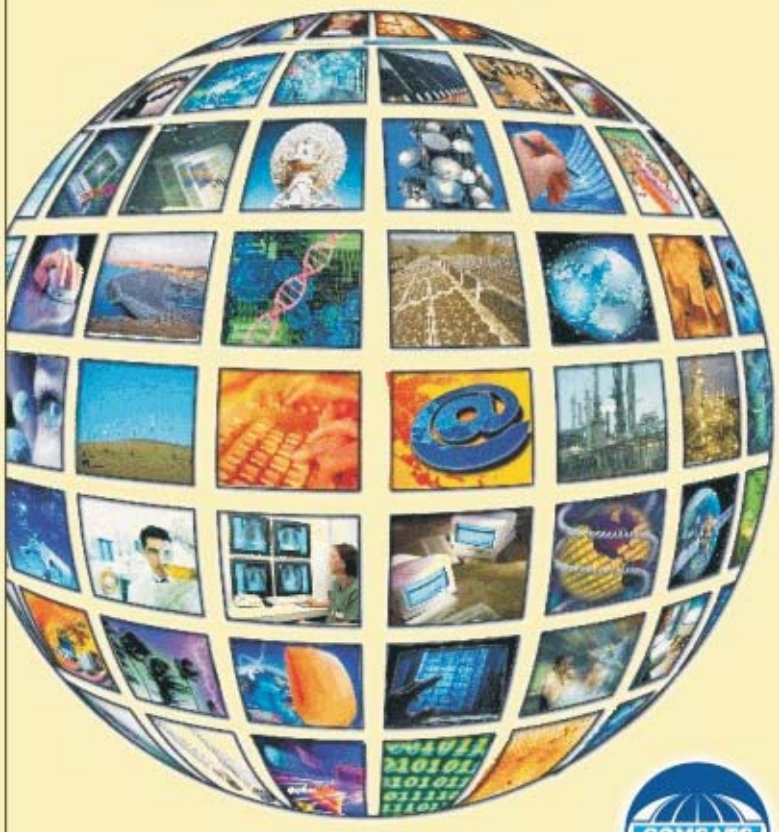
ROAD TO KNOWLEDGE-BASED ECONOMY



Editors

Hameed A. Khan
M.M. Qurashi
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Commission on Science and Technology for Sustainable Development in the South

10

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FOREWORD

We now live in an age where knowledge has become the key driver for socio-economic development. Countries that have realized this have marched forward rapidly leaving others behind. The Islamic World unfortunately belongs by and large to a group where little attention is being paid to knowledge, and there is maximum reliance on natural resources. This has resulted in a widening gap between the Islamic countries and the more advanced countries of Europe and South East Asia. Thus, the GDP of the richest Islamic countries remains less than even some of the smaller European countries as we tend to rely only on our natural resources rather than our real wealth which lies in the human resources. A small country like Singapore has annual exports of almost 350 billion US dollars and the population of Singapore is only 4 million. Comparing this with the exports of Pakistan that is about 18 billion US dollars and has a population of 160 million, one realizes what a vast difference education can make in the process of development.

This book intelligently examines these problems in detail and considers some of the many ways in which countries around the world are addressing them. The knowledge perspective has reinforced some well-known lessons, such as the crucial importance of universal education, and focused fresh attention on other needs, such as tertiary-education. It has also cast into sharp relief, the need to recognize and compensate for information-problems and the resulting market-failures.

In my opinion, this book has clearly identified knowledge-based economy and its importance, particularly for the developing countries. Starting from demystifying of the concepts and identifying fundamentals, and linking knowledge-based economy to sustainable development, the book comprehensively highlights areas in S&T knowledge where countries need to strengthen themselves.

The recommendations in the last chapter of the book will be very helpful in elaborating the policy-framework for the knowledge-based economies in the developing countries. It identifies policy related priorities that the governments needs to concentrate on, in order to succeed on the road to knowledge-based economy.

This book indeed adds to a series of highly informative and useful publications of COMSATS, produced under the able leadership of Dr. Hameed Ahmed Khan. I have had a long standing association with Dr. Khan and have always admired his work. I congratulate him on his valuable contributions to the sector of sustainable development, particularly with reference to his works on science and technology.

(Prof. Dr. Atta-ur-Rahman, FRS)
Chairman, Higher Education Commission (HEC) &
Adviser to Prime Minister on S&T

PREFACE

The world today is witness to an era of knowledge-revolution. Now, more than ever, knowledge is not only an intrinsic part of the economic system, but also the key factor that is determining the competitive edge of firms and countries alike, in this globalized world of today. Redefining the parameters of a traditional economic system, knowledge-based economy essentially emphasizes the use of ideas and technological resources, and relies greatly on innovation and education of workers who are capable of developing new skills to respond to the future challenges.

Understanding the dynamics of a knowledge-based economy is one thing; striving to achieve it as a nation is yet another phenomenon. What precisely are the various measures that a country can undertake to gear itself towards becoming a knowledge-based society and what are the policies and planning techniques that it can employ to ensure sustainable development — the building blocks of the Road to Knowledge-based economy. Indeed, for countries in the forerun of the world economy, the balance between knowledge and resources has shifted very far towards the former. Knowledge has perhaps become the most important factor determining the standard of living of the human race. Today's most technologically-advanced economies are truly knowledge-based. It is thus imperative that developing countries give serious thought to devising and implementing result-oriented strategies to initiate the process of bridging the increasingly widening knowledge-gap between themselves and the developed world, before it becomes impossible.

This book is an attempt to produce a reservoir of information pertaining to knowledge-based economy, which the developing countries may use in order to not only gauge their current standing and lag in achieving the status of a knowledge-based economy, but also to identify various broad steps, through which a meaningful transition may be achieved in not too distant a future. Given that the subject in discussion is both vast and cross-cutting, the book maintains a holistic approach from a policy and planning viewpoint throughout its content.

The first chapter of this book demystifies the very concept of knowledge-based economy while the second chapter is dedicated to the case-study of Pakistan, which deals with the prospective vision, strategy and action-plan for a developing country, that may lead it to the road to knowledge-based economy. The third chapter outlines the dynamics of the policy-framework governing S&T knowledge-generation and its appropriate utilization. The fourth chapter establishes an understanding of the vital linkage between knowledge-based economy and sustainable development. The next chapter touches upon the need for commercialization of knowledge. Realizing the dismal state of knowledge creation and utilization of S&T in developing countries, a thorough analysis of the R&D status, technology-commercialization and condition of higher-education is taken into account. This further leads to rounding up and

identification of best practices and examples from developing and Muslim countries across the globe. The sixth chapter advocates building indigenous capacities in the overall context, i.e., building both human and infrastructural capacities through better education and institutionalization of programs and networks for knowledge-based economy.

The seventh chapter, in particular, draws attention towards creating virtual and real networks to enable global knowledge-based economy that may benefit various countries, rich or poor, across the globe. The eighth and the last chapter suggests the way forward for developing countries through South-South and South-North collaboration and networking as well as exchange of scientific & technological resources.

A compilation of the thoughts and ideas of the authors are encapsulated in various chapters, which are comprehensive accounts both in their own right, as well as in the thematic context of this book. Great care has been taken to ensure homogeneity, coherence and authenticity of data/information. Any mistakes or discrepancies, however, are regretted and suggestions in this regard are most welcome.

Finally, I am profoundly grateful to Prof. Dr. Atta ur Rahman for taking out time to produce his knowledgeable contribution for this book. I would also like to thank Dr. Hasibullah, Dr. A. Ghaffar, Mr. Irfan Hayee, Ms. Zainab Hussain Siddiqui, Mr. Bilal Aurganzeb, Ms. Urooj Deedar, Ms. Narmeen Khalid, Mr. Shahid Zaka, Ms. Sadia Nawaz and Mr. Imran Chaudhry for their useful contributions to this book. Moreover, I would also like to thank Dr. M. M. Qurashi for his invaluable editorial input.

(Dr. Hameed Ahmed Khan, *H.I., S.I.*)
Executive Director, COMSATS

KNOWLEDGE AND KNOWLEDGE-BASED ECONOMY:
DEMYSTIFYING THE CONCEPTS AND IDENTIFYING THE FUNDAMENTALS

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1. INTRODUCTION

In the competitive globalized world of today, the role of knowledge for sustained development cannot be emphasized enough. The current era of knowledge-revolution is dictating the terms of progress for individuals, organizations and entire economies, whereby it is their sheer ability to generate, acquire and appropriately utilize knowledge that sets them on the path to prosperity. Undoubtedly, the driving force behind today's knowledge-era has been the rapid pace at which science and technology have flourished and made an impact in virtually every sphere and aspect of human life. It is, unquestionably, due to this impetus of S&T that the traditional economies of yesterday are now transiting into the knowledge-based economies of tomorrow.

Since time immemorial, knowledge has been at the centre of economic growth and improvement in the standard of living of mankind. The ability to create new knowledge and ideas, i.e. to invent and innovate in products, processes and organizations, has long been a fundamental source of progress and development. In fact, there have always been institutions in history that have created and disseminated knowledge, be it the medieval guilds, the Cistercian abbeys, the royal academies of science that emerged in the seventeenth century, or the large corporations of the early twentieth century. What distinguishes the ramifications of knowledge in earlier centuries and the 21st century is the very notion of a knowledge-based economy, which signifies a transition from the old pattern and building-blocks of an economy to a new one, which is fueled by the unprecedented speed at which knowledge is created, accumulated, utilized and depreciated, in terms of economic relevance and value.

Indeed, knowledge today is a weapon against cut-throat competition and a tool for gaining strategic and competitive advantage. It is the breeding-ground of innovation and has the quality of achieving different results when put to varying use. It is the means of improving the standard of living of men and women and also the force behind modern mechanisms engaged in the destruction of life and property. It is the guiding light of sustainable development initiatives, as well as the kindling spirit of unsustainable growth-mechanisms. Nevertheless, to what purpose knowledge has been used over time requires an independent study in its own right; however suffice it to say at this juncture, that never in the history of humanity has knowledge and its use

provided more useful possibilities for addressing the world's developmental challenges.

It is therefore imperative that a holistic account of the growing importance of knowledge for industrial structure, national economic performance, and sources of competitive advantage, for both firms and nations, must be taken, and the role of governmental-policy, which should be directed towards building capacities, facilitating collaboration within and between businesses, and encouraging competition, must be highlighted. However, for engaging in any in-depth discussion addressing the role of knowledge in transforming our way of life, our economy and, most importantly, our vision and perception of the future, it is of prime importance that, at the very outset, a thorough study of the basic notion of knowledge, as well as the associated concepts of knowledge-management, knowledge-society, knowledge-cities and, most importantly, knowledge-based economy is undertaken.

2. DEFINING KNOWLEDGE

Knowledge is an abstract notion, which is constantly and continually being defined. "Knowledge" is perhaps the simplest of words and yet one of the most cumbersome to explain. This is primarily due to its paradoxically straightforward and simple syntax and yet its profound vastness in terms of its semantics, as its concept has evolved and escalated over millenniums of human existence. As the report of CERI Washington Forum (June -1999) concluded:

'The science of describing, understanding, and measuring knowledge will always be an imperfect one. [Identifying knowledge at some forums has therefore] … turned out to be capricious: sometimes sticky, often slippery, rarely tangible, frequently tacit, and extremely heterogeneous'. (Brinkley, 2006 p.3)

Nevertheless, delving deeper into this subject, some plausible definitions do surface that explore the various aspects of, and perspectives on knowledge.

"Knowledge" can briefly be described as a person's understanding of something or the information he/she has about something. Knowledge is what is known. It is a 'noun' that has synonyms, such as 'cognition' and 'noesis'. Like the related concepts of truth, belief, and wisdom, there is no single definition of knowledge on which scholars agree, but rather numerous theories and continued debate exists about the nature of knowledge. Acquiring knowledge is essentially composed of complex cognitive processes: perception, learning, communication, association, and reasoning. The term 'knowledge' also implies: the sound understanding of a particular subject, potentially with the ability to use it for a specific purpose. In fact "knowledge" has numerous meanings, as given in dictionary. It is the state of knowing something, the familiarity, awareness or understanding acquired through experience or study, the sum of what has been perceived, discovered or learned, or simply, the specific information about something or someone.

Many synonyms of knowledge exist, including but not limited to: 'information', 'learning', 'erudition', 'lore' and 'scholarship'. These nouns indicate the presence of what is known. It may have been known through some particular incident, experience or study. Interestingly, 'knowledge' is the broad term that can be called a kind of an umbrella, under which all the others can be encompassed. To elaborate this discussion, let us look closely at a few of these synonyms. 'Information', for example, usually refers to a collection of facts and data. 'Learning' generally implies knowledge gained by schooling and study. 'Erudition' is used to describe some profound, often specialized knowledge of a particular domain. 'Lore' applies to knowledge that has generally been acquired through tradition or anecdote. And finally, 'scholarship' is considered to be the expertise of a particular area of learning or knowledge.

2.1 Tracing the History of Changing Definitions of Knowledge

Historically, the term "knowledge" seems to have a unique meaning, this was so considered by Plato, the ancient Greek philosopher and a student of Socrates. Knowledge, according to him, can be a statement that must be justified to be true and believed. Over the years, many other social scientists and philosophers have tried to verify this definition of knowledge and there are different views on it, even opposing ones. Aristotle, a student of Plato, believed that knowledge should be built upon experience, observations and reasoning.

After the above abstract and philosophical understandings of knowledge, the world witnessed a gradual proposition of knowledge definitions that were nearer to the practical world (Descartes, in Frost, 1946 p. 225). Pragmatists tried to elaborate on the definition of knowledge, on more practical grounds, and sought to eliminate the absurdities (Rousseau, 1972, p.132; Locke, in Frost, 1946, p. 107) and over-abstraction in the extreme ideals of the rationalists. They argued in favour of a knowledge based on observation, causation, and recognition of individual free will (Locke, in Frost, 1946, p. 117). Knowledge was also to be applied toward useful outcomes for the individual and his community (Rousseau, p. 129, Kant, 1960, p. 75). Writers later recognized a perspective accommodating an individual's experience (James, in Frost, 1946, p. 124; Dewey, 1938, p. 21) blended with the consensus of a co-knowing society. *Behaviorism* (Skinner, 1971, p. 16) argued that internal definition of knowledge was unattainable and not useful, and that knowledge should be considered as what could be observed and replicated only in the external environment. This purely behavioristic view has been successfully countered, with arguments that knowledge does indeed contain un-specifiable intrinsic components (Rogers, 1961, p. 193; Schon, 1987 p.8, p. 25).

The definition of knowledge has transformed, over an eventful history, from a general phenomenon to one that is specialized and actionable as pointed out by the behaviorists, in evidence "outside the person, in society and economy, or in the advancement of knowledge itself" (Drucker, 1993, p. 45-6). To complete this guideline for a contemporary definition of knowledge, to Drucker's external knowledge in

action, we must also add a condition validated and verified by Schon (1987, p. 25) and other writers that applying knowledge to action additionally requires an intrinsic or 'tacit' element.

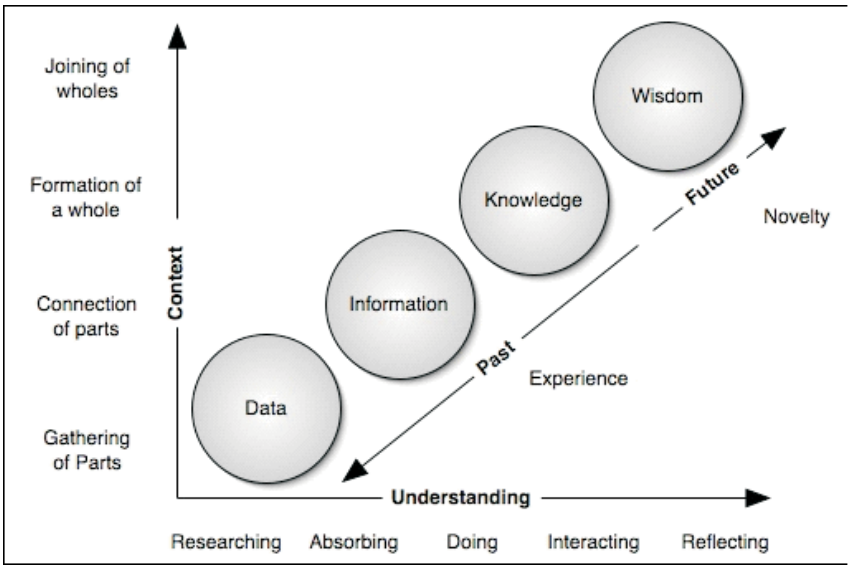
The definition of knowledge is a live, ongoing debate for scientists and philosophers. The classical definition, founded by Plato, in which the three basic criteria for the qualification of a statement to be knowledge are layed down as 'justified, true, and believed', is under much scrutiny. Some social scientists argue that these conditions are simply not sufficient. There are a number of alternative definitions proposed, including Robert Nozick's rationale for a requirement that knowledge 'tracks the truth' and Simon Blackburn's additional requirement that it should not be said that those who meet any of these conditions 'through a defect, flaw, or failure' have knowledge. Richard Kirkham suggests that the definition of knowledge requires that the believer's evidence is such that it logically necessitates the truth of the belief.

In contrast to this endeavour to define knowledge, Wittgenstein observed, following Moore's paradox, that one might say "he believes it, but it isn't so", but can not say that "he knows it, but it isn't so". He further argues that these do not correspond to discrete mental states, but rather to distinct ways of talking about conviction. What is different here is not the mental state of the speaker, rather the activity in which they are engaged. For example, on this account, to know that the kettle is boiling is not to be in a particular mental state, but to perform a specific task with the statement that the kettle is boiling. Wittgenstein tried to bypass the difficulty of definition by looking to the way "knowledge" is used in natural languages. He saw knowledge as a phenomenon of a family resemblance.

In the workable definition of Davenport and Prusak, knowledge is: 'a fluid mix of framed experience, contextual information, values and expert insight that provides a framework for evaluating and incorporating new experiences and information'. On dissecting the definition, two distinct yet interrelated aspects of knowledge are revealed. One, that there is content in knowledge, which is a mix of the outlined variables and inclusive of a certain things that we have within us, such as beliefs, values, feelings, experiences, information and motivation. And two, that there is a function or purpose of knowledge, which is to provide a 'framework for evaluating and incorporating new experiences and information'.

On the other hand, Clark (2004), opines that knowledge is gained through context and understanding. He asserts that when one has context, it is possible to weave various relationships of the experiences. As the context grows, so does the variety of experiences that an individual can possibly extract from it. Clark states that, once a greater understanding of the subject-matter is achieved, the individual is better able to translate experiences of the past into new knowledge by absorbing, doing, interacting, and reflecting. Thus, according to him, understanding is a sheer continuum, whereby data comes about through research, creation, gathering, and discovery. Next, information is created by the meaningful organization or presentation of this data.

The Continuum of Understanding



Source: Clark, 2004

Information essentially possesses the context. Knowledge, then, embodies the complexity of experience, which comes about by seeing it from different perspectives and angles. Thus, the key difference between information and knowledge is that the former is static, while the latter is dynamic. Wisdom, however, is the pinnacle of understanding. As with knowledge, one can share experiences that create the foundations for wisdom, however, this needs to be communicated far greater understanding of the contexts of the audience than with sharing of knowledge.

Data and information are related to the past and are based on the gathering of facts. Knowledge deals with the present by effectively becoming a part of us and enables us to perform. However, having gained wisdom is the starting point of dealing with the future as we envision it to be. Conclusively, Clark indicates an important point to remember, that often the distinctions between the data, information, knowledge, and wisdom continuum are not very clear and, therefore, his guidelines should be treated as the fluid rather than stark differentiations.

Peter F. Drucker has also given a functional definition of knowledge, referring to it as information that changes something or somebody – either by becoming grounds for actions, or by making an individual (or an institution) capable of different or more effective action. But finally, in a more global sense, one might say that knowledge is reliable information that can be put to work in the service of all men, and which can be communicated in comprehensible ways, so that people everywhere can become more

self-reliant and self-sufficient (MANAS, 1971). The second phrase of this explanation – which is more frequently used and closest to the definition of knowledge, particularly in the context of this book, –refers to the use of knowledge to produce economic benefits.

2.2 Characteristics of Knowledge

"He who receives an idea from me receives instruction himself without lessening mine; as he who lights his taper at mine receives light without darkening me"

(Thomas Jef Ferson)

The above quotation by Thomas Jefferson points at one of the most important and fundamental traits of knowledge – the fact that knowledge is the only resource that does not deplete by sharing and in effect has the potential to further enrich, once shared. Unlike other factors of production, such as capital and labour, knowledge is a non-rivalrous public-good. In pure economic terms, once knowledge is discovered and made public, the marginal cost of sharing it with others is zero. Although patents, copyrights and trademarks are barriers to knowledge-sharing, most of the knowledge is readily available to a large group of users.

On the other hand, the two key characteristics of knowledge, which allow it to revolutionize the world, are its 'velocity' and 'viscosity'. 'Velocity' is defined as the speed with which knowledge is spread. It relates to how quickly and widely knowledge is disseminated and is enhanced by the use of technologies, such as Information Communications Technology. 'Viscosity' is the 'richness' or 'thickness' of the knowledge transferred and is enhanced by the richness of the medium through which knowledge travels. 'Richness' essentially determines how much of the knowledge transferred has been absorbed and applied. This transference is only possible through a series of lecturing and hands-on experiences, because these are the only ways in which a recipient acquires large amounts of detailed knowledge over time (DFID, 2000).

However, increased velocity comes with a disadvantage. Velocity strips down knowledge to its bare essentials by removing portions of its context and richness; however it does allow it to move faster. This stripping can push knowledge down the continuum of understanding: from knowledge to information, or from information to data. Thus, it is quite possible that the intended knowledge-exchange may fail (Clark, 2004).

3. TYPES OF KNOWLEDGE

Although there are many types and kinds of knowledge, the two types most frequently referred to in the literature include 'explicit' and 'tacit' knowledge.

3.1 Explicit Knowledge

Explicit knowledge is 'knowledge that can be made available to another person for inspection' (DFID, 2000). In this sense, explicit-knowledge can be verbally explained, codified or written down. In short, this type of knowledge can be articulated into formal grammatical statements, mathematical expressions, manuals, etc. Explicit knowledge can be promptly transmitted to others and can be easily processed by a computer, stored in databases or transmitted electronically.

3.2 Tacit Knowledge

Tacit knowledge is essentially, that personal knowledge which is embedded in individual experience and comprises intangible elements, such as perspective, personal beliefs and value-system. It is often hard to translate into formal language and contains subjective insights and intuitions. A source of real competitive advantage for many countries and firms, especially the Japanese, tacit knowledge can be communicated only if converted into understandable words, models, or numbers. Moreover, tacit-knowledge has a technical and cognitive dimension to it. The technical dimension encompasses the informal skills pertaining to what is commonly known as the 'know-how of doing something'. For instance, a craftsperson will have difficulty in precisely articulating the technical principles that he uses in creating his piece of work. All highly subjective personal hunches and inspirations derived from bodily experience fall into this category of tacit knowledge. The other dimension of tacit-knowledge is cognitive. This aspect consists of beliefs, perceptions, ideals, values, emotions and mental models that are instilled in our minds. A very important facet of this dimension of tacit knowledge is that it shapes the way we perceive the world. However, this knowledge is quite difficult to properly articulate (Clark, 2004). When explicit and tacit knowledge complement each other, they generate a dynamic process, which leads to the creation of new knowledge. Moreover, knowledge is best generated when people with explicit and tacit knowledge interact (DFID, 2004).

4. KNOWLEDGE AS AN ECONOMIC GOOD

Having described the various aspects of knowledge and defined it in the specific context of this book, it is now important that a succinct account of the importance of knowledge with specific reference to its economic utility is undertaken.

It is common knowledge today that disparities in the productivity and growth of different countries have less to do with their lack or abundance of natural resources than with their ability to improve their quality of human resources and other factors of production. The World Development Report 1999 states:

'For countries in the vanguard of the world economy, the balance between knowledge and resources has shifted so far towards the former that knowledge has become perhaps the most important factor determining the standard of living - more than

land, than tools, than labour'.

Put differently, the distinguishing factor is the ability of a country to create new knowledge and ideas and to incorporate them with equipment and people. For the last two hundred years, neo-classical economists have recognised only labour and capital as the primary factors of production, while knowledge, productivity, education, and intellectual capital were all regarded as exogenous factors. Today however, knowledge and technology are two of the key-factors of production. In fact, knowledge is considered to be the basic form of capital, and economic growth is understood to be driven by the accumulation of knowledge. As the famous punch-line of Deutsche Bank's advertisement proclaims:

'Ideas are capital. The rest is just money'

Consequently, today the world is witness to a growing relative importance of knowledge-capital in total productive wealth since the early twentieth century, as well as the rising relative share of GDP attributable to knowledge-capital.

There are two major categories of knowledge-capital. One is the investment, which is geared to the production and dissemination of knowledge. This category includes investment in training, education, R&D, information and coordination. The other category of knowledge-capital is the investment that is focused upon sustaining the physical conditions of human-capital, for instance, investments made in healthcare. The OECD in 1999 gave an account of the various categories within which several developed countries have made knowledge-related investments. By this input-measure, three groups of economies can be identified:

- High knowledge-investment economies of North America, OECD, Asia and Japan—investing around 6 per cent of GDP
- Middle knowledge-investment economies of Northern Europe and Australia—investing between 3 and 4 per cent of GDP, and
- Low investment-economies of Southern Europe—investing between 2 and 3 per cent of GDP (Brinkley, 2006).

For OECD countries, the annual investment-rates have grown at an average annual rate of 3% since the 1980s. The investment-structures, however, differ from one country to another. For instance, Scandinavian countries spend more on public education, while the US spends most on industrial investment, such as, private-sector R&D, software and information-technology equipment. Nevertheless, it was as early as the end of the 1960s that the current value of the stock of knowledge-capital in the United States, which was devoted to knowledge-creation and human-capital, began to outweigh that of physical capital, such as infrastructure, equipment, inventories and natural resources (Ernst & Young, 1999).

5. THE NOTION OF A KNOWLEDGE-BASED ECONOMY

Various points of view exist when it comes to defining what exactly a knowledge-based economy is. The likes of Peter Drucker essentially argue that we have a knowledge-economy because knowledge is an ever more important input in 'sidelining both capital and labor'. Other economists and scholars insist that the knowledge-economy is one where knowledge is a more important product than ever before. Furthermore, a third point of view asserts that codified knowledge has now become a more significant part of economic relations, while the fourth school of thought argues that it is essentially the changes and improvements in information and communication-technologies (ICTs) that harness a knowledge-based economy (ibid). Because of the varied ways in which knowledge-economy is interpreted, testable definitions of this term are difficult to state. However a number of general definitions of the knowledge-based economy are given below:

"… one in which the generation and exploitation of knowledge has come to play the predominant part in the creation of wealth. It is not simply about pushing back the frontiers of knowledge; it is also about the most effective use and exploitation of all types of knowledge in all manner of economic activity" –
DTI Competitiveness White Paper 1998.

"economic success is increasingly based on the effective utilisation of intangible assets, such as knowledge, skills and innovative potential, as the key resource for competitive advantage. The term "knowledge-economy" is used to describe this emerging economic structure" – ESRC

"the idea of the knowledge-driven economy is not just a description of high-tech industries. It describes a set of new sources of competitive advantage, which can apply to all sectors, all companies and all regions, from agriculture and retailing to software and biotechnology" – Charles Leadbeater

"an economy in which all sectors and agents are enriched with knowledge, a source of new industries as well as of renewal of established ones, factor of competitiveness as well as of improvement of social welfare" –
(Reiffers and Aubert, 2001).

"a knowledge-driven economy is one in which the generation and exploitation of knowledge play the predominant part in the creation of wealth" – United Kingdom Department of Trade and Industry

'We define the knowledge-economy as production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence. The key-component of a knowledge-economy is a greater reliance on intellectual capabilities than on physical inputs or natural resources'- (Carlaw, Oxley & Walker, 2006).

Reading through all these definitions, a few essentials of a knowledge-driven economy become quite clear:

- Innovation is a permanent feature
- It is an economy of networks at different hierarchical levels
- It embodies new forms of organization that involve industrial cooperation, polarization, and relations between public and private sectors
- Human-capital plays a fundamental role, and the capacity to learn is more important that the level of knowledge
- Codified and distributed tacit-knowledge is useful, and
- Proliferation of information-related activities is evident in all sectors of the economy.

For a country's economy to be called a knowledge-based economy, enriching human-capital is absolutely critical. This is primarily due to the fact that for making investments in technology, a country must have sufficient human-capital, which is defined as the 'formal education, training and on-the-job learning embodied in the workforce' (Ernst & Young, 1999). The implication of the knowledge-economy is that there is no alternative way to prosperity than to give high importance to learning and knowledge-creation, in the industrial era, wealth was created by using machines to replace human labour. The knowledge economy essentially dwells on 'knowledge-workers', who are symbolic analysts, able to manipulate symbols rather than machines. These include, besides others, architects, bank-workers, fashion-designers, pharmaceutical researchers, teachers and policy-analysts. More than 60% of workers in advanced economies like the US are essentially knowledge-workers (ibid).

The theory of New Growth-Economics suggests that a country's capacity to take advantage of the knowledge-economy is dependent on how quickly it can become what is called a 'learning-economy'. Learning does not only constitute using new technologies to access global knowledge, but also involves using them to communicate with other people about innovation. In a learning-economy, individuals and firms are able to create wealth, in proportion to their capacity to learn and share. In a nutshell, life-long learning is absolutely vital for organisations and individuals.

From a more sectoral angle, it is observed that the knowledge-driven economy develops high-technology industries, mainly in ICT and services, which are the major sector for providing jobs. This however does not imply that all jobs, require high qualifications. The role played by physical capital decreases in favor of intangible capital, which comprise education, training and applied knowledge that can be acquired though domestic R&D or by accessing the global stock of knowledge. Due to such developments, organizational structures and practices have changed to offer more decentralized managerial structures. These constitute networks, systems of information, monitoring processes, marketing, and interfaces connecting users and clients (ibid).

In a nutshell then, according to the World Bank, a knowledge-based economy contains the following five features:

i. An economic and institutional model providing incentives for the efficient creation, dissemination, and use of knowledge, in order to promote growth and increase social welfare;
ii. An educated and skilled population, able to create and use knowledge;
iii. An innovation system composed of firms, research-centers, universities, consultants, and other organizations that are capable of tapping into the growing stock of global knowledge, adapting the knowledge to local needs, and transforming this knowledge into products that the markets value;
iv. A dynamic information-infrastructure capable of facilitating the effective communication, dissemination and processing of information.
v. A collection of such intangible factors that make a society function efficiently and move forward,. e.g., the capacity to formulate a vision, the level of trust and self-confidence, and the appropriateness of guiding values.

6. THE ESSENTIAL DIFFERENCE BETWEEN TRADITIONAL VS KNOWLEDGE-BASED ECONOMY

The major difference between a knowledge-based economy and a traditional economy is in the way that knowledge is generated and introduced into the production- process. In traditional economies, the knowledge-component or innovation, typically takes the form of exogenous ideas; however, in a knowledge-based economy the knowledge is created and used as an integral part and intrinsic component of the process of designing and implementing new business-activities and products. This systematic use of knowledge as a production-factor gives rise to products whose value is progressively less embedded in their physical components and more in the knowledge- component (TKEAS, 2004).

Other differences between the traditional economy and knowledge-economy include, the fact that in a traditional economy, the process of distribution doesn't change the products; products are as they are once and for all. In a true knowledge-based economy, information does not only circulate, but also grows and develops in moving from person to person. Furthermore, the economics of a knowledge-based economy is not of scarcity, but rather of abundance. Unlike most resources that are depleted when used, information and knowledge can be shared, and actually grow through application. On the other hand, the effect of location is either diminished by the use of appropriate technology and methods, or on the contrary, reinforced in some other economic fields, by the creation of business-clusters around universities and research-centers. Laws, barriers and taxes are also difficult to apply on a national basis, as knowledge and information leak out. Products or services enhanced by knowledge also command price-premiums over comparable products (Wikipedia, 2006). It is argued by some that the emergence of a knowledge-based economy is a major departure from the traditional economy and that it offers endless productivity-gains,

faster non-inflationary growth and ever rising stock-markets. It is further argued that the ICT- revolution has allowed firms to exploit S&T knowledge-bases to give them a unique competitive edge, with falling cost of transaction and processing. This has given rise to new organisational forms and a radical shake-up in employment-relationships as more and more knowledge-workers became portfolio-workers, freelancers, or self-employed. This view, however, took a blow in the wake of the 'dot-com' crash.

However, in reaction to the hype created by the 'dot-com' crash, an opposite view has emerged that questions the very existence of a knowledge-based economy. Proponents of this thought argue that the economy has always been driven by knowledge leading to innovation and technical change and knowledge-based institutions have helped store and share knowledge for centuries. What is being witnessed today is, in fact, more of the same but operating on a bigger scale and at a faster pace. The truth, however, lies somewhere between the two schools of thought. As David and Foray describe, in a paper published in 2002 the move to a knowledge or knowledge based economy is essentially a sea change or soft discontinuity, rather than a sharp break from the past (Brinkley, 2006).

7. ENABLERS OF A KNOWLEDGE-BASED ECONOMY

Having to save extent, described what a knowledge-based economy truly is and what the key differences between it and a traditional economy are, one must take a look into the enabling-factors that have allowed for the transformation of yesterday's traditional economy into tomorrows knowledge-based economy.

There are a number of factors behind the transformation of a traditional economy into a knowledge-based one, including, globalization of communications and commerce; commoditization of ICTs, the increasing role of scientific research in innovation, advanced integrative information-infrastructure; modularization, vertical disaggregation, and outsourcing, and the expansion of value-chains and clusters with new categories of actors (AKKE, 2005). The two major forces namely S&T and globalization, are the primary triggers of the rest of the enablers, and these are discussed below:

7.1 Science and Technology – the Building Blocks of a Knowledge-based Economy

Science and technology are the driving forces of a knowledge-based economy. It is through both basic and applied research in S&T that the world has seen a complete revolution in virtually every walk of life and the economic sphere. Whether it is better machines, new theories, improved medicines, breakthroughs in healthcare, more durable consumer-goods, non-perishable food, impenetrable defence-weaponry, or the introduction of efficient and effective communications-systems, science and technology have added, and will continue to add, to the core knowledge-base of a knowledge economy in every aspect of life through the sheer power of unprecedented

innovation.

The creation of scientific knowledge is essentially based on systematic enquiry grounded in the methods of scientific observation, objectivity, classification and theory-development. Through these means, the world can be better explained and once understood, can become easier to shape and control. History has it that as science expanded, so did the demands on it by the growing industrial economy and society. The growth of new applied disciplines of engineering, metallurgy and mining became important and new universities, based around delivering these, areas of study arose.

According to Kuhn (1962), S&T does not grows through the falsification of existing paradigms, but in fact by making a move to a new paradigm. Movements in ideas therefore occur through scientific revolutions when a new paradigm overthrows an existing one. He further argues that during non-revolutionary periods, normal science takes place within the dominant paradigm (Carlaw, Oxley & Walker, 2006).

The role of research and development is a critical component of the innovation-system. R&D is essentially the breeding ground for most technological breakthroughs that we had and continue to witness today. R&D is not only a domain of institutions and universities, but equally so of industries, organizations and businesses. The knowledge created from R&D activities however, can and cannot be a public-domain and therefore, its fruits may not be available to all. Nevertheless, most of the R&D, applied or basic, once embedded into products and services does not only ensure that the benefits are shared but also adds to the universal pool of knowledge on a particular subject or in a specific field.

Technological breakthroughs, rather than having a one-off impact, have the potential of creating technical platforms for further innovations, and this technical-platform effect is a key driver of economic growth. Technology can raise the return-on investment, which is how knowledge-based economies sustain growth. Traditional economics predict that there are diminishing return-on-investment, however in contrast, non-rivalry and technical-platform effects of new technology can lead to increasing rather than diminishing returns on technological investment.

Within the realm of technologies, the role of ICT's in propelling knowledge-based economies to newer horizons cannot be sidelined. ICT's are the enablers of change. They do not by themselves create transformations in society, but are essentially, the facilitators of knowledge-creation in innovative economies. ICT's also assist in unleashing the creative potential and knowledge embodied in people. Indeed, the ICT-sector has a powerful multiplier-effect in the overall economy compared with manufacturing. In fact, wealth-generation is becoming more closely tied to the capacity to add value using products and services of ICT(Ernst & Young, 1999).

These facts however, must not obscure the importance of other realms of knowledge besides S&T. Knowledge-based economies are not restricted to the realm of high-

technology, but S&T do tend to be central to the new sectors, giving momentum to the upward growth of the economy as a whole.

7.2 Globalization – the Ultimate Enabling-Factor for Knowledge Economy

The phenomenon of globalization has paved way for much of the world's knowledge-based economies. Globalization is primarily characterized by the stretching of social, political and economic activities; the growing magnitude of interconnectedness and flows of trade; the speeding up of global interactions and processes; and, the growing extensity, intensity and velocity of global interactions (Held D. and McGrew A., 1999). This greater interconnectedness has paved way for 'global-firms' or 'transnational-corporations', which are defined as 'firms that try to simultaneously realize gains from experience-curve economies, location economies, and global learning, while remaining locally responsive' (Hill C., 1997).

Having emerged with a global face from the opportunities provided by the privatization, liberalization, deregulation and export-led economic growth strategies induced by structural-adjustment programmes in peripheral economies, TNCs are dominating the world with their sheer size and scope. In essence, 90% of all TNCs are based in developed countries and more than half come from just five nations – France, Germany, the Netherlands, Japan and the United States. According to K. Lokayan, the largest TNCs far outstrip the many developing and even many developed-countries in terms of economic output. He states that the combined revenues of General Motors and Ford exceed the combined GDP for all of Sub-Saharan Africa. At least 51 of the largest 100 economies in the world are corporations (Lokayan K., 2001).

The World Investment Report 2002 defines an international production-system as a mechanism whereby, TNCs locate different parts of the production-processes, (including various service-functions across the globe) to take advantage of fine differences in cost, resources, logistics and markets (UNCTAD, 2002, pg. 117). These advantages are assumed in a coordinated trans-border production-system through a complex mechanism of strategies complemented by structures. It involves not only the creation of manufactured-goods, but also, all value-added cross-border activities in extractive, manufacturing and the services-sector (UNCTAD, 1993).

With the advent of information and communication technologies (ICT), the vision of a near-perfect competition is becoming a reality. While new markets have opened up and prices have dropped, consumers can also find out the prices offered by all producers. Furthermore, competition is fostered by the increasing size of the market, opened up by these technologies. Those products with a high knowledge-component generate higher returns and offer greater growth-potential. More importantly, competition and innovation go hand-in-hand. Although knowledge spreads quickly, for a firm to remain competitive it must be able to innovate more quickly than its competitors.

On the other hand, capitalists search the globe for the best returns and are always looking for innovation. This has lead to the globalisation of capital. Information-technologies have helped accelerate the pace at which capital continually circulates in search of maximum investment opportunities. Consequently, it is no longer geographical distances that determine a capitalist's ability to secure fertile investment grounds (Ernst & Young, 1999).

Globalization is seen as a key-driver and determinant of change across the developed and most of developing-world, and the dramatic increase in international-trade and investment-flows, over the past decade, is indeed attributable to this phenomenon. The knowledge-based economy is therefore emerging as a key factor for restructuring of international-trade in some advanced countries, that is looking to high value-added services. Over the past decade, the UK has witnessed a boom in the export of services, associated with the knowledge-based economy, such as financial services, computer-services and business services. In current terms, knowledge-based service exports of the UK were worth £76 billion in 2005 (Brinkley, 2006).

8. KNOWLEDGE-SOCIETY AND KNOWLEDGE-CITIES

The knowledge-society is defined as:

'A larger concept than just an increased commitment to R&D. It covers every aspect of the contemporary economy where knowledge is at the heart of value-added from high-tech manufacturing and ICTs through knowledge intensive services to the overtly creative industries, such as media and architecture' –
(Kok Report, 2004).

It can also be defined as 'a formal association of people with similar interests, who try to make effective use of their combined knowledge about their area of interest, and in the process contribute to this knowledge'. In this sense, knowledge is the psychological and useful result of perception, learning and reasoning
(Wikipedia, 2006).

The main feature of a knowledge-society is that knowledge forms a major component of any activity within that society, particularly economic activities. A huge volume of knowledge and information dictates the economic, social, cultural, as well as all other human activities within that society. Knowledge and information are vital components for the formation of any society, because every society is formed around some shared concepts. Knowledge-societies, however, are not a new occurrence. For instance, fishermen have long shared the knowledge of weather-prediction with their community and this knowledge adds up to the social capital of the community. Nonetheless, what is new is that with current technologies, knowledge-societies need not be constrained by geographic proximity. Currently, technologies are offering many more possibilities for sharing, archiving and retrieving knowledge, and knowledge has become the most important capital in the present age, implying the success of any

society that succeeds in harnessing it. Unequal distribution of wealth results in unbalanced and inappropriate development of society. Imbalances of knowledge, its distribution, availability, sharing. hinder the socio-economic and cultural development of societies. Thus, knowledge-societies fundamentally realize the importance of knowledge, its proper distribution, sharing and building for social development (ibid).

Another concept closely related to that of a knowledge-society, is that of knowledge-cities. According to Ergazakis, Metaxiotis & Psarras, (2006), 'a knowledge city is a city that aims at a knowledge-based development, by encouraging the continuous creation, sharing, evaluation, renewal and updating of knowledge. This can be achieved through the continuous interaction among its citizens themselves and at the same time between them and citizens of other cities. These interactions can be supported through developing the knowledge-sharing culture, designing city's appropriate, as well as provision for proper IT networks and infrastructures.

The very process of developing a knowledge city is neither quick nor simple. This is primarily due to the reason that this concept refers to many different aspects of life in a city. Therefore all stakeholders of the society and the city such as local government, citizens, private sector, organizations and universities, must be taken in to confidence before any efforts are instigated to develop a knowledge city. The entire process requires an in-depth analysis of the current situation, definition of a vision and strategy, and implementation of an action plan with particular attention to key aspects such as the revitalization of traditional-infrastructures and investments in technology-infrastructures.

The main advantage of a knowledge-city is that, by definition, it functions in such a way that is in favour of its knowledge-based development. Other benefits of a knowledge city, on a local level, include strong dynamics of innovation across all sectors of economic and social activity, better educational services, creation of knowledge-communities, actively involved citizens in the development of their city, creation of more and well-paid employment, faster growth in community's income and wealth, revitalization of traditional industries, a boost to tourism, a boost to the city's pride and confidence, creation of a environment tolerant towards minorities and immigrants, greater opportunities to share wealth through investment in the public domain, and better funding of social safety nets (Ergazakis, Metaxiotis & Psarras, 2006).

9. KNOWLEDGE-MANAGEMENT

Knowledge-Acquisition is about extracting knowledge from sources of expertise and transferring it to a Knowledge-Base. Knowledge-Management can also be defined as the efficient utilization of the existing intangible, knowledge-related resources, available in every sector of the economy, to enhance the productivity of all factors of production. Knowledge-Acquisition is a large process itself and is composed of five stages, which will be explained in more detail. The explicit management of

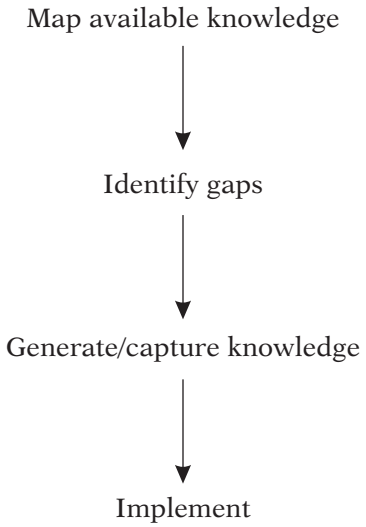
organizational knowledge or knowledge-management is increasingly a competitive response in many organizations. The traditional view of knowledge-management has treated knowledge in terms of pre-packaged or taken-for-granted interpretations of information. However, this static and contextual knowledge works against the generation of multiple and contradictory viewpoints that are necessary for meeting the challenge posed by wicked environments (Wikipedia, 2007)

A simple phrase that encapsulates a core aspect of Knowledge-Management is "getting the right knowledge to the right people at the right time in the right format".
According to Thomas Bertels Knowledge-Management is defined as:

"Knowledge management is the management of the organization towards the continuous renewal of the organizational knowledge-base; this means e.g. creation of supportive organizational structures, facilitation of organizational members, putting IT-instruments with emphasis on teamwork and diffusion of knowledge (as e.g. groupware) into place."

Knowledge-management complements and enhances other organizational initiatives such as total quality management (TQM), business process re-engineering (BPR) and organizational learning, thus providing a new and urgent focus to sustain competitive position.

Knowledge must be managed effectively to ensure that the basic objectives for existence are attained to the greatest extent possible. Knowledge-management in organizations must be considered from three perspectives, with different horizons and purposes:
i. *Business Perspective* - focusing on why, where, and to what extent the organization



must invest in or exploit knowledge. Strategies, products and services, alliances, acquisitions, or divestments should be considered from knowledge-related points of view.

ii. *Management Perspective* - focusing on determining, organizing, directing, facilitating, and monitoring knowledge-related practices and activities required to achieve the desired business strategies and objectives.

iii. *Hands-On Operational Perspective* - focusing on applying the expertise to conduct explicit knowledge-related work and tasks. (On the Management of Knowledge - Position Statement by Karl M. Wiig, February 6, 1996)

The KM development-process proceeds as follows:

A Knowledge-Management system, which may be as simple as a story or as complex as a million-dollar computer-program, captures a snapshot of the person's knowledge-representation. This is called knowledge-harvesting. In the case of a story, the knowledge representation is passed onto others by means of a verbal snapshot. In the case of a computer-program, it resides in a database that may be utilized by others. It is only a "snapshot", as further experiences and learnings within the creator may change the knowledge-representation, while the snapshot remains the same.

Others may make use of the knowledge-representation "snapshot" by using the story or tapping into the KM system and then combining it with their prior knowledge. This in turn forms a new or modified knowledge-representation. This knowledge representation is then applied to solve a personal or business need, or explain a phenomenon. To serve customers well and remain in business, organizations must: reduce their cycle-times, operate with minimum fixed assets and overheads (people, inventory and facilities), shorten product-development time, improve customer-service, empower employees, innovate and deliver high-quality products, enhance flexibility and adaption, capture information, create knowledge, share and learn. None of this is possible without a continual focus on the creation, updating, availability, quality and use of knowledge by all employees and teams, at work and in the market-place

To become knowledge-driven, companies must learn how to recognise changes in intellectual-capital in the worth of their business and ultimately in their balance-sheets. A firm's intellectual-capital including; viz employees' knowledge, brain-power, know-how, and processes, as well as their ability to continuously improve those processes, is a source of competitive-advantage.

9.1 Knowledge-Acquisition, Storage and Organization

Knowledge-acquisition includes the elicitation, collection, analysis, modeling and validation of knowledge for knowledge-management projects.

Knowledge-acquisition is all about the gathering of knowledge. Organizations must

never try to gather every bit of knowledge, as this can be quite time and resource consuming. It is always advisable to find one or two good sources to work from. For example, Hill & Knowlton, a New York based public-relations firm that has offices and clients scattered across the globe, found that an enormous amount of its knowledge was tied up in emails. So, it implemented a system that allows strategically important email to be saved in a data-repository that can be called upon by others when needed.

On the other hand, knowledge organization is "the description of documents, their contents, features and purposes, and the organization of these descriptions so as to make these documents and their parts accessible to persons seeking them or the messages that they contain. Knowledge-organization encompasses every type and method of indexing, abstracting, cataloguing, classification, records management, bibliography and the creation of textual or bibliographic databases for information retrieval." (Anderson 1996) .

In short, it is an arrangement, or organized structure for arranging or classifying of knowledge, in order to facilitate the use of documents or recorded knowledge. The term "knowledge-organization" taken literally means making knowledge an "organum" (Greek = instrument, aid) for particular purposes" (Kiel, 1994).

9.2 Knowledge-Distribution

“Knowledge-Distribution means being concerned with the media for the distribution of the knowledge; the structure, form or language that the knowledge is represented in; and processes or procedures for its management and creation.”

The increased usage of electronic-media, such as computers, for distributing knowledge has during the last decade been almost explosive, e.g. the growth in usage of the Internet for communication, thus giving rise to and enabling new means of knowledge-distribution. Electronic-media has helped overcome time and space constraints while sharing knowledge between individuals separated by physical boundaries, and has made it easier to record, store, search, and retrieve it. Bob Metcalfe, the inventor of Ethernet-technology (the enabler that allowed the information genie to jump out of the bottle), has a law named after him -- Metcalfe's Law, "the asset-value of a computer network increases exponentially as each new node (individual user) is added to it." This is because each new user brings along a wealth of new linkages and resources, so the total network-value becomes far richer than the mere sum of its parts. This is what gives the Internet its power. Gilder's Law - the total band-width of communication-systems will triple every 12 months - describes a decline in the unit cost of the net, which in turn allows more information to be distributed over the net.

9.3 Knowledge-Application

Knowledge-Application is the key to packaging knowledge to ensure widespread use,

converting specialized information into practical tools, and putting new knowledge into practice in the real world. Knowledge-Application is the actual use of the knowledge and is generally measured by its effectiveness and usefulness. Thus, if you have bad information going in, you will have bad information coming out. To insure that good information goes in, users should be involved, from day one, in the planning, design, and building of the system. Knowledge-application refers to an organization's timely response to technological change by utilizing the knowledge and technology generated into new products and processes.

For the effective implementation of knowledge-management program, there are several drivers or motivations. First among them is to gain the competitive advantage that comes with improved or faster learning and new knowledge-creation. Knowledge-management programs may lead to greater innovation, better customer-experiences, consistency in good practices and knowledge-access across a global organization, as well as many other benefits, and knowledge-management programs may be driven with these goals in mind.

10. CONCLUSIONS

James Madison, the fourth President of the United States once said:

'Knowledge will forever govern ignorance; and a people who mean to be their own governors must arm themselves with the power which knowledge gives'.

Developing countries need to transform from a brick and mortar economy into a more knowledge driven economy and for that it is necessary to make a reassessment of strategies for growth and development. In a global economy, which is increasingly being driven by knowledge, businesses all over the world are affected very substantially by intellectual-property considerations and new innovations; new patents and designs have become daily occurrences. The good news is that the Knowledge, Economy is still evolving from relatively backward circumstances. The present is not at the end of history. It is merely a start-up venture without a clear understanding of where to go. An ample dose of quantitative humility may be the right medicine for futurists to swallow now, before they plunge ahead with prognostications that lack a balanced view of the realities of economic worth (Strassmann, 2000).

The rest of the book will explore ways in which knowledge is linked to sustainable-development and methods through which developing countries might transit into a knowledge-based economy.

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NATIONAL SCIENCE, TECHNOLOGY AND INNOVATION: Vision, Strategy and Action-Plan

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I. INTRODUCTION

Stunning advances made in the last few decades in the fields of information-technology, biotechnology, materials sciences, health sciences, renewable energy and other disciplines, are rapidly changing the face of the globe, leading several countries on the path of social and economic development, leaving others behind. The pace of knowledge-generation and its impact on new product and process development and the emergence of new interdisciplinary areas, e.g. nanotechnology and post-genomic sciences, are providing opportunities for nations not traditionally recognized with science leadership to leap-frog many of the advanced "G8" countries. Some of these new emerging areas have provided opportunities to nations that were not traditionally classified as scientifically and technologically advanced countries.

Information technology has transformed the world into a global village and is providing major opportunities for growth, e.g. through e-commerce. Access to mobile phones and Internet is opening up new opportunities for communications through wireless technologies in remote villages, where no fixed phone-lines exist. Business outsourcing from technologically advanced countries is paving the way to tap into the creative potential of our youth. The economies of certain countries, such as Ireland, China and India, have been transformed significantly with the help of Information-Communications Technologies (ICT). The ICTs differ from other technologies because these do not simply act as a source of revenue for business and government, but also accelerate the full process of development and innovation in many ways through improvement of communication and exchange of knowledge-information. The intrinsic cross-cutting nature of ICT is resulting in improved productivity in industry and agriculture and is creating enormous new opportunities for businesses around the world.

Biotechnology has also emerged, in recent years, as a powerful medium for socio-economic development. A large number of biotechnologies are being developed that include recombinant vaccines, vaccines in drug-delivery, molecular diagnostics, bioremediation, sequencing of genomes, bioinformatics development, genetically modified crops, and recombinant therapeutic proteins. Multi-billion dollar industries are being developed in many of these fields and countries like Cuba that are investing

massively in such technologies and have now begun to benefit in a major way.

New materials are having a major impact on a large number of industrial sectors, including the electronics, automobile, engineering, polymers and plastics, textiles, and construction sectors.

Recent advances in nanotechnology are leading to exciting new concepts for development of new materials for engineering, chemicals, pharmaceuticals and other sectors. Nanotechnology in the field of health-applications covers a wide variety of products involving the development of diagnostic tools, delivery of drugs and vaccine development of new types of surgical devices, treatment of various diseases, and detection of different pathogens. Nanotechnology can also impact access to pure water and affect sanitation, through development of nano-membranes and nano-clays as well as through recycling and remediation of water, including the use of nano-porous polymers to purify water and remove toxic metals. Similarly, application of nanotechnology in the field of renewable energy, through the development of solar cells, hydrogen-fuel cells and nano-photovaltaic devices, as well as carbon-nanotubes, are rapidly developing.

Hydrogen fuel-cell technology is predicted to be one of the most important energy-production technologies, in which hydrogen could be the source of clean energy, starting from either water or methanol as a raw material. BMW has recently unveiled a prototype car that has a hydrogen-powered internal combustion-engine. Other companies are also working intensively in this area and it is expected that, within a couple of decades, petrol may be largely replaced by hydrogen fuel-cell technology.

New knowledge, particularly knowledge related to technology, drives the economic systems. Economic agents, including firms and governments, are forced to adapt to technical change in order to survive in a competitive environment. While governments should act as facilitators, the necessary capabilities in new technology must be developed in enterprises. This will only be possible if we strengthen our universities and R&D organizations and create effective linkages between them and industry. It will be the increasing use of knowledge in the production-processes and service-industry that will determine the growth of our GDP. Our ability to compete or survive in the globalization of economic systems depends on our commitment towards the development of human-capital and ensuring a continuous learning-process within the governmental- institutions and enterprises to create a culture of innovation.

Innovation is concerned with enhancing national productivity and national competitive-performance. Dynamic innovation-systems involve an interplay between a number of different parts of the society, which include the government, the private sector, the universities and research institutions. The transition of our economy from an agriculture-based economy to a knowledge-based economy involves a mosaic of complex interactions, in which a large number of players would be involved. The universities will need to play a central part in this transition through creation of

knowledge, as well as the use and diffusion of new knowledge into the society through establishment of technology-parks, business-incubators, access to venture-capital and other such schemes.

The new world-order requires us to prepare our children to face the challenges of the global economy. This needs imparting a substantially different type of education, focused not only on the mastery of subject-matters but also on development of the various other skills, such as, the ability to think critically; innovate; communicate effectively; work efficiently in teams; develop entrepreneurship and risk-taking skills, and the ability to face and manage changes in a flexible manner. This would require a massive focused national effort. While investment towards development of high-level S&T manpower is necessary to meet the critical shortage of teachers and researchers, equally important is the investment in development of skill at technical education and management-levels and the provision of quality education to the majority of our population.

We need to develop and introduce a system of incentives that attracts our brightest youth towards scientific careers and a system that supports and rewards innovation. This would require investment in building an infrastructure for research, and facilities, and training institutes for continued-training to deepen the knowledge and development of the skills of researchers. We need to strengthen or establish Centres of Excellence in those areas that are relevant to our social and economic requirements. These Centres should be equipped with facilities provided in the world's best institutions, including a top-class faculty with internationally comparable pay-scales. The scientists or researchers in these Centres of Excellence should be encouraged to work on contract-research, commissioned by the industry or be allowed a sabbatical for six months to work with industry. The Centres of Excellence should not only be a source of new knowledge but also be equipped with state-of-the-art laboratories to provide metrology, testing and standards services. The creation of national standards, metrology and testing facilities are essential for economic development.

We need to create knowledge-networks through the collaboration of government's research laboratories and industry at the regional, national and international levels. Regional-knowledge-networks can be developed through collaboration of industrial clusters with the local universities. Regional firms in turn must collaborate with each other to share knowledge about latest production-practices and quality-management. Collaboration between local firms, public institutions and multinationals are essential to transfer capabilities in jointly executed projects. Our industrial and trade-policies must encourage local technology-firms and engineering-enterprises, through continuous upgrading of technology and skills and access to markets; small industry must be encouraged to convert into medium-sized ones and medium-sized industry into large ones. Collaboration with the relevant international knowledge-networks can help our industry enter global value-chains.

The essential component of a National System of Innovation are the high quality

knowledge-workers or researchers. Pakistan, presently has only about 120 scientists/engineers in per million population engaged in R&D as compared to 2500-3000 scientists/engineers per million population in the advanced countries. We should therefore, target to reach a similar figure per-million-population (500,000 Ph.D. level scientists by 2025) if we are to participate in a knowledge-economy.

The changing global face of science is leading to science becoming an increasingly multidisciplinary area, in which institutions in many countries must participate together. Development of technology is now closely interlinked with the developments in various scientific fields, and we cannot just expect to become technologically self-reliant, unless we have the necessary strength in both basic and applied sciences. Basic science is what feeds the science-parks, where innovation and utilization is made. It has been proved time and again that discoveries in the basic sciences of today become the basis of major commercial products of tomorrow. Pursuit of new knowledge and its application for invention should become a part of the social fabric. In a competitive world of knowledge-based economies, keeping abreast with the latest technology is not sufficient, it requires direct engagement in science, technology, innovation and discovery. For this an "out-of-the-box" thinking and bold decision-making would be required. An example of how such decisions can have a major impact on the national economy is as follows: When I was the Federal Minister (Govt. of Pakistan) responsible for Science & Technology (including Information Technology) in the previous government, I had examined in some depth the reasons why mobile-phony had not grown in Pakistan for the previous eight years that it had been in existence. It turned out that the reason was simple and obvious but had never been addressed previously. Anyone who had a mobile-phone had to pay for receiving a call! It was therefore a general reluctance in the public to subscribe to mobile-phones, as subscribers had to pay for calls that are made by others to them. I decided to change this and bring in the regime "Calling Party Pays" (CPP). This one step made a sea change in the growth of the telecommunication sector in Pakistan. By the time, when I had left as the Federal Minister, responsible for Information Technology, in October 2003, there had been a several hundred percent growth in mobile-phony in Pakistan, with the number of mobile-phones expanding exponentially. This growth continues unabated and it has become the single most important sector of our economy today, highlighting how critical decisions in key areas can impact entire economies.

Another important decision which I took was to explore the field of renewable-energy for providing electric power to the country. The project was accordingly initiated by the Ministry of Science and Technology under my direction, to collect nationwide wind- data. The project was executed by the Pakistan Meteorological Department (PMD) and the data was collected over the period of two years. As a result, a site has been identified near Gharo, Sindh, which has potential of producing 10,000 MW of electricity in the area, which is 60 kilometer wide (Gharo – Keti Bander) and 180 kilometer long (from coastal area uptil Hyderabad). The pre-feasibility of the site at Gharo has been carried out and it has been verified by national and international companies such as, General Electric and Vestas. These companies are willing to invest

US$800 million to produce 583 MW of electricity from the wind-energy during the next 2-3 years without any financial liability on the part of the government. In the short-term 880MW of electricity can be produced by the year 2010 from the wind-energy and supplied to the national grids. This can be magnified to 3000 MW of electricity by the year 2020.

The price on which the electricity will be supplied will be initially 6 cents per kilowatt-hour and it will later be dropped to 3-4 cents per kilowatt-hour after few years. The potential for the production of electricity through wind-energy is therefore greater than the production of electricity through large dams that the government is planning to build, and it can be done without any financial involvement of the government.

The area of renewable-energy is therefore another important priority-field, which can be exploited not only using wind-energy but also solar, hydroelectric, biomass, hydrogen-fuel cells and other vast emerging-technologies for national development.

Presently, none of the universities in Pakistan are ranked among the top 500 universities in the world. The neglect of the higher-education sector in the past 50 years has resulted in a system where the graduates lack basic skills in communication, ability of critical thinking and analyzing information to cope with the diverse requirements of the challenges posed by a knowledge-based economy. We are striving to include at least 2-3 of our universities in the bracket of the top 500 in the next ten years. Sustainable economic development in the highly competitive world-market requires a major effort in the generation of knowledge, innovation and invention. The cycles of poverty and dependence will only be broken by major investments in national higher-education programmes and committing to reach an allocation of 1% of GDP for higher-education sector. Pakistan has neglected its higher-education, science and technology sectors for over 50 years and major commitment to redress the decaying infrastructure is required.*

The growing inequality in our society is a threat to our social, political and economic stability. At the same time, it is a fact that this inequality stems from our neglect in the development of education and science & technology sectors. Knowledge-based economy cannot thrive or survive in a social climate where a large section of the population, in fact, is excluded from the benefits of economic growth. We need to recognize that policies concerned with the development of human-capital, science & technology and innovation should lead to a raise in per-capita GDP, employment-generation and poverty-alleviation. Consequently they need appropriate and sustained investments, they take time to work and they will not be helped by frequent changes in objectives or national commitments.

* In a recent study (Nature, 15 July 2004, pages 311-316), a direct relationship has been shown between the quality of science output of a nation and the health of its economy. The countries occupying the top eight places in the science citation rank order (USA, UK, Germany, Japan, France, Canada, Italy, Switzerland) produced about 84% of the top 1% most cited publications between 1993 and 2001. PPP GNI is gross national income converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GNI as a U.S. dollar has in the United States.

II. VISION, POLICY-GUIDELINES AND OBJECTIVES OF THE PROGRAMMES

Recognizing the key role that science and technology now play in socio-economic development, I propose the following objectives and policy-guidelines for Pakistan's scientific and technological capacity-building:

- To use science and technology as a vehicle for alleviation of poverty, elimination of hunger and malnutrition, provision of clean air and drinking-water, enhancing livelihood-security, reducing regional imbalances, creating opportunities for employment and for creating an environment in which our people can live with dignity.
- To ensure the impregnation of science in our society so that the science-culture permeates into every sphere of our national activity, and contributes to the development of a progressive and enlightened society, in which science is the corner-stone of all national sectoral policies.
- The higher education and S&T policy be targeted towards creating culture of innovation. It will be through our indulgence in innovation that will determine our comparative strength and ability to compete in the world-markets. Innovation is not just creation of new products, but also relates to changes in value-addition and productivity increase brought about through skill-development and technology, efficient management of production and services and their marketing.
- To promote scientific research in academic and research-institutions in the country, thereby creating an environment of research that attracts the brightest of our youth to take up careers in science and technology. For this purpose, Higher Education Centres and Institutes should be established and maintained as world-class Centres of Excellence in key disciplines, so that they can contribute to the development of cutting-edge science and technology in the country, and where the youth of the nation can feel the excitement of extending the current frontiers of science to new horizons.
- To ensure that academic and research-institutions work in an atmosphere that is free of bureaucratic hurdles and with complete autonomy, so as to foster creativity and promote the science and technology enterprise in the country.
- To support the technology-upgrading of small and medium sized firms through easy access of technology, its adaptation and absorption through reverse-engineering.
- To provide incentives to Firms (tax incentives, low-interest loans & others) for setting up of in-house R&D centres and for continuous training of their workers.
- To promote collaborative research between public R&D organizations/ universities and private firms through supporting joint technology related projects and by encouraging mobility of scientists from universities/R&D organizations to private companies.
- To give special emphasis on the transformation of S&T research-output to new products and processes through access to venture capital and technology-development fund.
- To establish public libraries, science-parks, technology-incubation centres and

science-museums for promotion of science-culture and diffusion of technology.

- To establish policy-research institutes, staffed with scientists and economists, entrusted to carry out research on several aspects of policies related to technological capacity-building. This institute should regularly carry out foresight-studies identifying niche- areas for development.
- To use post-genome technology to ensure food-security on a sustainable basis. Simple technological solutions for harvesting, storing and transporting exist and should be implemented.
- To strengthen basic sciences and establish linkages with applied sciences, such as agricultural sciences, engineering sciences, materials sciences, information technology, biotechnology, pharmaceutical and space sciences.
- To strengthen the regime of Intellectual Property Rights in order to foster creativity and protect the rights of inventors.
- To promote efforts to provide speedy access to all kinds of information at affordable costs, utilizing electronic communication wherever possible.
- To promote S&T cooperation between institutions in Pakistan with leading international institutions in order to develop a strong network of international linkages that can help in transfer of knowledge.
- To encourage research in engineering, electronics, communications technologies, agricultural sciences, biotechnology, energy, chemicals and pharmaceuticals and new materials.
- To encourage research and development in livestock farming and dairy so that animal-proteins can be made available to a large segment of our population. Accessibility of animal-proteins to our children is vital for their normal growth and development and prevention of protein-energy malnutrition, which is quite prevalent in this country.
- To encourage research in the field of natural disasters, particularly drought and its related fields, including promotion of biosaline agriculture, desertification, reclamation of saline-soils, water-management and optimum use of water-resources.
- To support multidisciplinary research so that new scientific knowledge can be closely inter-linked with various disciplines and translated into economic benefits.
- To encourage the spirit of scientific enquiry in all areas including social aspects and to promote the development of bioethics so that new problems that are being constantly thrown up by advances in science, can be properly addressed without harming ethical and religious values.
- To strengthen mechanisms for science advisory by strengthening the organizations such as Engineering Council, National Science Council, the Pakistan Academy of Sciences and other professional societies that can be engaged for reliable counsel.
- To take all other necessary steps to transform Pakistan into a major world-class player in order to harness the power of science and technology for socio-economic development and national security by providing the requisite financial support, compatible with international norms.

III. STRATEGY AND IMPLEMENTATION-PLAN

In order to implement the objectives outlined earlier, specific sectoral projects and programs need to be identified with well defined time-lines, budgetary resources and deliverables, some generic strategies and requirements are given bellow:

1. Governance

i. The set-up of governmental organizations concerned with Higher Education/Science and Technology needs to be substantially strengthened so that they are transformed into action-oriented bodies of highly competent and talented scientists and engineers tasked to achieve a set of specific objectives.
ii. Think-tanks should be set up in various sectors, such as agriculture, engineering, biotechnology, information technology, pharmaceuticals, basic sciences, renewable-energy, materials sciences, post-genome sciences, nanotechnology, space sciences, water-resources and desertification. Each team of professionals should work closely with the relevant ministries in order to achieve well defined targets. Science and Technology should become a centre piece for policies of all of the relevant ministries.
iii. The programs should include an external critical peer-review mechanism for the performance of each ministry and appropriate remedial measures should be taken where performance is unsatisfactory
iv. Each Ministry in the Government should set aside a certain part of its overall budget towards promotion of S&T programs and indigenous technology development. Such activities should be undertaken in close coordination with the Ministry of Science and Technology and the Higher Education Commission.

2. Human-Resource Development

i. Universities and Research-Centers need to be strengthened by the induction of high quality Ph.D. level faculty (300-400 Ph.D. level faculty-members in each university and 50-100 Ph.D. level researchers in each research-institute) in order to provide the quality manpower needed for development of our educational institutions, services and production-industry.
ii. The advanced countries have 2500-3000 scientists/engineers per million population and they form the backbone of their developmental process. Pakistan only has about 120 scientists and engineers per million population and needs to develop at least 500,000 high quality scientists/engineers over the next ten years in carefully selected fields. Massive postgraduate-level training-programmes need to be launched by the Higher Education Commission for the purpose. The trained manpower should be provided with infra-structure, facilities, research funding and a high-salary structure so that the scientists and engineers can be usefully employed in the national development-process. Organizations under the Higher Education Commission, as well as those

under the Ministry of Science and Technology and other relevant Ministries, need to work closely together to identify the areas of national importance and to arrange the requisite postgraduate training-programs.

iii. We need to train and retain high quality S&T manpower by offering attractive salary-structure and a conducive environment for research. For this contractual system of appointments with an appropriate salary-structure to attract the best of our human resources into the scientific profession should be introduced in higher education and S&T institutions of the country, subject to regular performance-assessment.

iv. The Government should initiate an ambitious programme to ensure that it enthuses the indigenous S&T community, as well as offers incentives to our top-class scientists from technologically advanced countries to return to Pakistan. The reversal of brain-drain should be a high priority for any country wishing to develop its economy.

3. Science-Education in Schools, Colleges and Universities

i. There is a serious mismatch between the capabilities of school-graduates and the need for highly advanced skills by the industry. Vocational training-institutes of world-standard should be established by the upgradation of existing institutions and by providing top-class faculty and appropriate laboratories. Private sector must be consulted for regular update of curricula. All technical college-graduates must receive about 6 months training in the relevant industry. There is also a need for promoting a culture of continuous and life-long learning so that the skills can be constantly improved and upgraded.

ii. A special program for improving science-education in secondary and higher secondary schools should be introduced so that students can learn subjects like physics, mathematics, biology, chemistry and computer sciences. This would involve not only improving the curricula but also ensuring access to quality teachers and teaching tools. All science-students in high school and secondary schools should study mathematics, physics, chemistry and biology, whereas students in other subjects should also be required to study mathematics along with one other science-subject. We must invest in establishing science-laboratories at all over our urban and rural schools. Our students must be exposed to the excitement of learning by doing.

iii. The shortage of science-teachers can be addressed by introducing a system of contract-appointments for unemployed graduates. The minimum qualifications for school-teachers must be B.Sc./B.A. and not matric. We need to train a core of good teachers of science and maths and should consider introducing "merit pay" or other incentives to reward and retain them in this vital profession.

iv. In order to introduce quality and accountability in our education-system we must benchmark all our educational institutes. A regular audit in terms of quality of students produced by schools/colleges, judged by an internationally

known criteria can introduce competition and quality in our education-system.

v. The 2-year B.S. program in colleges should be systematically replaced with the 4-years B.S. program and all current undergraduate programs in the universities should be changed from 2-year to a 4-year curriculum. Universities not having undergraduate-programs should introduce these on a priority basis.

vi. Some of the existing colleges should be converted from just those offering B.A./B.Sc. degrees to "Community Technical Colleges"; which should produce skilled manpower in areas such as, electronics, mechanics, medical technology, refrigeration, plumbing, design, computer programming and production-technologies.

vii. Linkages should be established with suitable international agencies (such as UNESCO, Inter-Academy Panel, National Academy of Sciences-USA, etc.) in order to improve the quality of school level science-education.

viii. S&T education must also be coupled with the study of social sciences so that acquisition of expertise in science and technology is strongly connected with ethical values and considerations.

ix. To ensure that academic and research-institutions aim to achieve 'world-standards', and carry out international quality research, academic audits should be implemented and the outcome should be matched by funding. Such assessments are now commonplace in all scientifically leading nations.

x. The universities should maintain properly equipped workshops with highly qualified personnel for repair and maintenance of costly equipments in science departments. [(+)]

xi. National Libraries (including digital libraries) should be established for higher education S&T that can provide access to all the important international journals of science, engineering and technology.

4. Leadership in Management

It is important to develop leadership and management-skills, which are acutely lacking in Pakistan so that science and technology institutions can be headed by persons who are not only eminent scientists but also possess the necessary leadership and management-skills to strengthen such institutions. Sustained economic development is based on strong institutions.

5. Priority Areas

The following areas need to be given high priority so as to have the necessary impact of the S&T efforts:

[(+)] In the recent ranking of top 500 universities, none of the institutions of Pakistan emerge, while 3 from India (Indian Institute of Science at position 258, Indian Institute of Technology, Delhi at position 457, Indian Institute of Technology, Kharagpur at position 458) and 2 from Turkey (Hacettepe University 453, Istanbul University 488) to make it to this distinguished list. In a 10-year framework, Pakistan should aim to get at least 4 institutions in this prestigious list.

a. *Basic sciences (physics, mathematics, chemistry, biology):* Selected departments in each university should be substantially strengthened through induction of highly qualified human-resources and necessary facilities and research-funding provided so that they can work in an environment conducive to creation of new knowledge.

b. *Applied Sciences:* Certain national priority areas in applied sciences should be promoted, including Engineering Sciences, Information Technology, Agricultural Sciences, Biotechnology, Materials Sciences (including nanotechnology) Chemicals and Pharmaceuticals, Energy, Water and Space Sciences. Investments in these fields should be focused with clear targets. Major R&D funding should be made available for projects of national significance to achieve the set objectives in different fields.

c. *Establishment of Mechanisms for Linking the R&D effort to Socio-economic development:* Mechanisms should be introduced to link R&D efforts to industry, agriculture, services and defense sectors (incentive schemes, tax-holidays, technology- parks, access to venture-capital, etc.). Duty-free import of machinery and capital-equipment should be allowed for R&D activities.

d. *Quality Assurance:* We need to create awareness about "Quality" in all our institutions, particularly the educational educations and the production-sector. Our socio-economic development in the knowledge-based economy will depend on the quality of our human-resources and export-oriented products and commodities.

6. Science, Innovation and Invention

i. Special emphasis should be given on the translation of new knowledge into new-technological products, ensuring the development of small, medium and large-sized industries in the country. Mechanisms should be introduced so that the benefits of technological growth reach the vast masses with the aim of impacting and improving the quality of life of every citizen of the country. In this context, Science-parks should be developed with interdisciplinary ethos where the best of scientists and technologists from all disciplines are attracted.[*]

ii. 'Technology-foresight' exercises should be regularly carried out to assess the present and future needs of technology, the niche opportunities for Pakistan and the projected impact of such technologies on social, economic, health and environmental aspects. Efforts are needed to promote R&D and technological innovation, to introduce technologies through strategic incentivisation and to

(*) These Science Parks could have a major accelerator such as a synchrotron light facility, a highly advanced multi-disciplinary scientific tool, as its centre piece; something which many of the emerging economies have established recently including Singapore, Thailand, Korea, China, India and Brazil. In Thailand and Korea, the synchrotron light centre has been created next to Science and Technology Park. In Australia, similar effort is being made.

diffuse technologies to the production-sectors, for which effective mechanisms need to be developed and implemented.

iii. The Higher Education, Science and Technology programmes should be developed with local requirements in mind, so that socio-economic benefits for the society can be achieved quickly and consequently a commitment from the society can ensure a sustainable investment in science, innovation and discovery.

iv. It is important to develop appropriate steps to encourage innovation and entrepreneurship. This would involve a close cooperation between government-departments, universities, Ministry of Science & Technology, Higher Education Commission and the private sector.

While it is important to encourage basic research and development of new product and process, in the short and medium-term, high priority should be given to acquire foreign-technology and to initiate programmes of reverse- engineering, in order to understand and absorb such technologies, leading thereafter to adaptive research, as well as domestic R&D in basic sciences.

7. Establishment and Strengthening of Centres of Excellence

We need to develop a competitive edge in the changing global scenario. World-class Centres of Excellence should therefore be created in selected priority-fields so that Pakistan becomes internationally competitive and in some cases leading in a 10-year framework. These Centres should be tasked to nurture high-quality talent in various fields of science and engineering and to establish linkages with industry, agriculture and health, and to tackle major national problems. Centres of Excellence should also be established in technology-development and technology-commercialization.

8. Promotion of Inter-Disciplinary Research

Knowledge-based economy requires highly qualified manpower, trained in multidisciplinary skills. Our technical colleges and university-training programmes should encourage multidisciplinary learning. A mechanism should be introduced allowing scientists to switch fields in order to promote inter-disciplinary learning and research. This may require modification in the academic and governance-structure of universities and colleges. The reform should include promotion of interaction of the physical, biological and earth scientists with academics in humanities and social sciences.

9. Promotion of Commercial Research

There is need to develop a corporate-culture for scientific institutions so that their output can be utilized. R&D institutions should therefore, set up strong commercial units that can develop effective liaison with industry. These units should be properly funded; be managed by suitable senior-level marketing-personnel and be given

appropriate funding so that they can invest in areas-of-importance for commercialization and strong marketing initiatives can be undertaken by the institutions.

i. Programs should be introduced to ensure mobility of scientists and engineers between universities, research-institutions and industry. Joint programs between academia and industry should be facilitated through a funding-scheme under which research projects jointly submitted by universities and industries are funded.
ii. R&D institutes should be given the privilege to patent their output and should also have the right to charge fees for licensing technology to industrial firms and units.
iii. Property-rights, especially intellectual-property rights on information development, such as software development must be enforced and legally protected so that the work of scientists and engineers gives them the legal ownership of the new discoveries.
iv. One of the major obstacles for utilization of the results of research is the absence of process-engineering companies in Pakistan, which can take the design-data of pilot/demonstration levels and provide total turn-key technology to the industrial sector. Such institutions need to be developed urgently.
v. Persons working in academic and research-institutions should be encouraged to act as consultants to industry with additional emoluments, and to share the financial benefits from any patents that are granted for their work so that there is an incentive to work on industry-related applications of research.
vi. The industry of Pakistan must be encouraged to sponsor contract-research at the R&D institutes, primarily in those cases that have commercial viability and value. South Korea and Japan as also most developed countries have successfully employed this strategy and 50-70% of its R&D costs are met by the industry. India and other developing countries have also taken up this initiative.
vii. Mechanisms should be introduced to offer incentives to the private-sector to encourage R&D efforts at the industry through access to venture-capital, tax-incentives, and sharing of costs by government for such research. Banks and other financial institutions should be directed to provide soft-loans for establishing R&D units on less than the prevailing markup/commercial rates. The government in turn should make it mandatory for the private-sector to spend a certain percentage of their profit on R&D activities according to the needs of the country and in areas where R&D can lead to the development of import-substitute products and help enhance exports.

10. Trust-Fund for Science and Technology

A Science and Technology Trust-Fund can be created by applying a cess (Pooling Tax) to all private sector economic activities. The Trust Fund should be operated by the

Technology Cluster Council comprising four members nominated by chambers of Commerce, two eminent scientists and two government officials one each from Ministry of Industry and Ministry of Science and Technology. By establishing transparent procedures the Fund can focus on activities related to skill development and funding joint projects in public, private partnership. Public/private partnerships are critical if science and technology are to benefit society.

11. Scientific and Technological Services

It is important to initiate a major national programme in the area of scientific and technological services including survey work related to scientific statistics and standards in order to ensure the optimization of the innovation-process.

12. Promotion of Indigenous Knowledge

Measures should be taken to protect and make use of indigenous knowledge for national development including areas involving biodiversity, protection of genetic resources and use of traditional knowledge, and skills and their applications in medicine and other fields.

Development of indigenous technology and indigenous products should also be encouraged, including engineering and fabrication of local machineries required in various industries.

13. Women in Science & Technology

To encourage women to adopt careers in science and technology, special programs should be introduced to identify the brightest women committed to research in S&T, and steps taken to promote their careers through the provision of grants/scholarships, etc.

There is a need to provide wider access to S&T education and employment-opportunities for girls and women in order to maintain gender-equality. The existing gender-disparity has resulted in depriving the nation from help of its intellectual productive potential.

14. Legal Infra-Structure

The legal infra-structure needs to be put in place in order to ensure acquisition of new technologies, their adoption, absorption and propagation. A national technology-transfer policy needs to be formulated in consultation with all ministries. This should guarantee that a technology-transfer process is built-in in respect of all major national projects so that development of technological competence and indigenous self-reliance is made compulsory in every national project. Technology-transfer should be regulated appropriately to ensure that licensing agreement accompany a certain

percentage of skill and knowledge transfer. For example involvement of local engineers during assembly of plants/machinery, purchasing of blue prints and technical training of personnel to work on similar plants overseas.*

15. Promotion of High-Technology

The proportion of hitech products is increasing in world trade. Pakistan share of total exports in hitech products is insignificant. We have achieved competence in several state-of-the-art technologies, including aerodynamics, thermal imaging, precision manufacturing, computational-fluid dynamics, electric-magnetic compatability, design and testing and encryption. The scientists working at the defense-organizations have made breakthroughs in several cutting-edge technologies, such as growing laser-crystals, design and manufacture of precision-optical parts for giant CMS projects at CERN, design and testing of ASIs and manufacture of laser land-leveling devices. These technologies need to be commercialized through public/private partnership.

The national defence-organizations are a repository of considerable skills in instrumentation, control and advanced-material handling. Extending or converting these skills to civil use could broaden our industrial skill-base considerably and would help us develop hitech industries.

16. Quality Assurance

Quality assurance is a vital aspect for industrial growth that has remained largely neglected. Rigid quality-standards for testing and accreditation need to be established for each industrial sector in order to meet the challenges imposed by WTO. The requirements of WTO including the imposition of non-tariff barriers to trade, on growth of our industries can be very negative, unless we have adequate research-laboratories whose certifications are internationally accepted. An internationally recognized accreditation-system should be incorporated in all major laboratories of the country so that exports of our products can be certified to meet the minimum quality-criteria laid down by international buyers. High-level national "Standards" institutions should be established to provide assistance to industry and other national organizations. Scientific centres of international standards should be developed in major industrial cities like Karachi, Lahore, Faisalabad and Quetta, with suitably trained personnel and equipment, so that they can meet the quality-certification demands of WTO/ private-sector industries. The universities and R&D organizations should also prepare their laboratories for certification of international level to meet the analytical demands of testing and standardization.

17. Public Awareness of Science and Technology

i. It is important to ensure that the central role of science and technology in

(*)Both Malaysia and South Korea used technology policies to encourage FDI for joint venture in export industries

national development is realized by the society, and awareness of its importance permeates into every sphere of our activity. For this a number of programs need to be undertaken that should include the use of mass-media (TV, radio, newspapers, etc.) highlighting science and technology in an interesting and attractive way. Nation's leaders including Member of National Assembly (MNAs) should become the spokespersons for communicating the message of 'the importance of science and technology in combating poverty'. In this connection, the impact of science and technology on our lives and the effects that it is having on social, ethical, moral, legal and economic aspects need to be emphasized.

ii. Recent developments of biotechnology have opened up moral, legal and health issues (such as the use of GM crops in terms of safety). These issues and their proposed solutions need to be widely understood.

iii. The importance of science and technology and the excitement that it provides to researchers needs to be widely disseminated among students through establishment of science museums, planetaria, botanical gardens, as well as through interesting television-documentaries.

iv. There is a need to develop strong linkages between S&T with social sciences and humanities so that S&T do not work in isolation of the society as a whole.

18. International Linkages

It is important that close linkages between S&T institutions in Pakistan be established with world-class institutions in technologically advanced countries. This can be done through through exchange of personnel and promotion of joint-research programs between institutions. International alliances and linkages between S&T institutions in Pakistan with international institutions can also be encouraged by funding programs and projects allowing exchange of scientists. Specific initiatives should be undertaken under which institutions, universities and research-centres in Pakistan can be twinned with world-quality research-centres abroad in order to promote S&T endeavour.

19. Monitoring Implementation

In order to ensure the successful implementation of the plan it is necessary to continuously monitor and assess the implementation of the plan through indicators of the performance. These should include the level of enhancements of the country's national S&T statistical indicators. The collection and dissemination of S&T statistics shall be made regularly, systematically and efficiently so that the monitoring of recent trends and comparison-trends of other countries can be clearly judged. The S&T policy can then be monitored through the evaluation of S&T programs in terms of, (a) number of publications of Pakistani scientists and engineers included in the Science-Citation Index, (b) number of scientists and engineers produced and employed, (c) number of Pakistani Ph.Ds. in science produced and employed, (d) number of internationally accredited laboratories, (e) technology balance-of-payments, (f) investments in high-technology areas, (g) contribution of technology based industries

to the GDP as a percentage of the total contribution of industrial growth, and (h) others.

20. Continuous External Assessment

A continuous process of self-assessment as well as external assessment should be introduced to ensure that the goals and targets are met and the plans are being properly executed according to a pre-determined time-frame for each activity. Methods should be introduced so that external peer-review could be carried out regularly of various science-institutions.

Standardized national training-programs should be implemented in selected fields, such as computer-sciences to ensure that persons who are coming in such fields are properly qualified.

National Committees of experts, not exceeding three/four members, should be constituted in each discipline to regulate the implementation of the policies, and monitor the development and progress of R&D activities of both the public institutions and private sectors/industries.

21. Strengthening of the Pakistan Academy of Sciences

The Pakistan Academy of Sciences needs to be substantially strengthened and transformed into an academy of international stature. It's mission should be to promote national research-policy and should act as a catalyst for initiating the establishment of a number of high-quality S&T institutions. This could also take the role of a science-funding body or could have a separate arm that deals with research-fundings in a manner similar to Research Councils in the UK or National Science Foundation and National Institute of Health in the United States. Alternatively, the Pakistan Academy of Sciences could be modelled on the pattern of the Chinese Academy of Sciences. The Pakistan Academy of Sciences may take the lead in collaboration with PCSIR, PCRET, NPSL and PSF to start programs through reverse-engineering for manufacturing of household appliances, basic scientific instrumentations and other useful items.

IV. BUDGET

The Government should make an annual increase of 0.2% of its GNP each year towards science and technology till it reaches 3% of GNP over the next 10-year period. This increase in annual allocation should become a mandatory part of the budget and should be considered an essential component for national development and defence. A similar increase of 0.2% of GNP should be made annually for the Higher-Education sector till it reaches 1.0% of GNP over the next 4 years and reaches 2.5% in 10 years.

National-Science Fund: A major National-Science Fund should be set up (at least 0.5%

of GNP) so that S&T Parks can be created with the remit of engagement in leading-edge and its translation into products with direct socio-economic benefit to the country in national areas of priorities.

V. CONCLUSIONS

The challenge for Pakistan is to develop a competitive edge at the global level for sustainable development. This will be determined by the ability of our nation to create, acquire and use knowledge for socio-economic development. The Science & Technology and Higher Education sectors have to play a critically important role in the transition towards a "Knowledge-based Economy". It is only if we are armed with the right knowledge and skills that we can improve our living-standards and provide a decent future to our children.

POLICY-FRAMEWORK FOR THE KNOWLEDGE-BASED ECONOMIES IN DEVELOPING COUNTRIES

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1. THE KNOWLEDGE-DRIVEN ECONOMY

Some define the knowledge-driven economy as 'one in which the generation and the exploitation of knowledge have come to play a predominant part in the creation of wealth. It is not simply about pushing back the frontiers of knowledge; it is also about the more effective use and exploitation of all types of knowledge in all manner of economic activity'. There are four structural forces driving economic transformation: revolutionary changes in information and communications technology (ICT); rapid scientific and technological advancement; ever increasing global competition; and shifting consumer-demand. Knowledge has fundamentally different characteristics from ordinary commodities and these differences have crucial implications for the way a knowledge-based economy must be organized. Most importantly, knowledge is now a global public good: it is 'infinitely expansible' or 'non-rival in consumption'.

In what ways are the laws that govern the new economies different from those of the old? To be sure, we still face the economics of scarcity. But just as the importance of land in production changed dramatically as the economy moved from agriculture to industry, so does the movement to a knowledge-based economy necessitate a rethinking of economic fundamentals. Knowledge is different from other goods: it has many of the central properties of a public good, indeed of a global public good. While the government has a key role in protecting all property-rights, its role in terms of intellectual property-rights is far more complicated: the appropriate definition of these rights is not even obvious. And in the knowledge-based economy, the dangers of monopolization are perhaps even greater than in industrial economies.

2. EDUCATION - THE FOREMOST PRIORITY

Foremost priority must be given to education of all types and at all levels. It should now be realized that Pakistan's vast population can be transformed into a valuable developmental asset by equipping all its people with the requisite knowledge and skills. No matter what a country may be lacking, intellectual capacity. The development of this very native but it is never short of the capacity to its full potential will require an enormous commitment and effort by the entire community. Leaders of Pakistan need a clarity of vision and foresight to see that knowledge in all its forms offers a key to the country's emergence as an economic power.

Investment in Education: Human resources are the most important determinant of overall development. But full exploitation of Pakistan's enormous human potential will require a shift in national priorities to commit a much greater portion of the country's financial resources for the educational sector. The total governmental spending on education of Pakistan compares unfavourably with countries such as Mexico, which invests 5.5% of GNP and 23% of total governmental spending on educational. A doubling of investments in our education sector is the means to double the country's GDP.

Expanding the Nation's Corps of School Teachers: A tremendous increase in the number of teachers will be required to support a quantitative and qualitative improvement in the country's school system. The training of such large numbers will require the establishment of additional teachers' training colleges and much larger budgetary allocations for teachers' salaries.

Expansion of Schools and Classrooms: A tremendous expansion in the number of schools and classrooms will be required to foster a quantitative and qualitative improvement in the country's school system.

Role of Private Sector: Such a dramatic improvement in the quantity and quality of the nation's educational institutions cannot be achieved without enlisting the full and active participation of the private sector in the expansion and upgradation of educational facilities and operations. Introduction of latest curricula, upgrading the teaching skills and standards, more efficient management of schools and financial resources, and innovation in methods of teaching will all require strong involvement by private corporations. This can be achieved by introducing policies to encourage investment in education and by providing incentives for delivering high-quality educational content to poor sections of the population.

Computerization of General Education & Vocational Education: Mere quantitative expansion in classrooms and teaching staff is an inefficient way of tackling a nation's educational deficit in the age of computer. Recent experience has proven that computerization of education, i.e. utilizing computer and computerized teaching materials as instruments for general education, can drastically improve the quality of education and speed up the knowledge-acquisition, while gradually decreasing dependence on the knowledge and skills of teaching staff.

A fundamental policy-decision should be made to fully utilize the capacities of computers for general education, not just for computer-training. A major launch will have to be the initiative to convert the entire school curriculum to computer-based, CD-Rom teaching materials.

An effort for computerize, can be extended to include not only general-school curriculum but also vocational training on a very wide range of occupational skills, which can then be made accessible through private and public vocational training

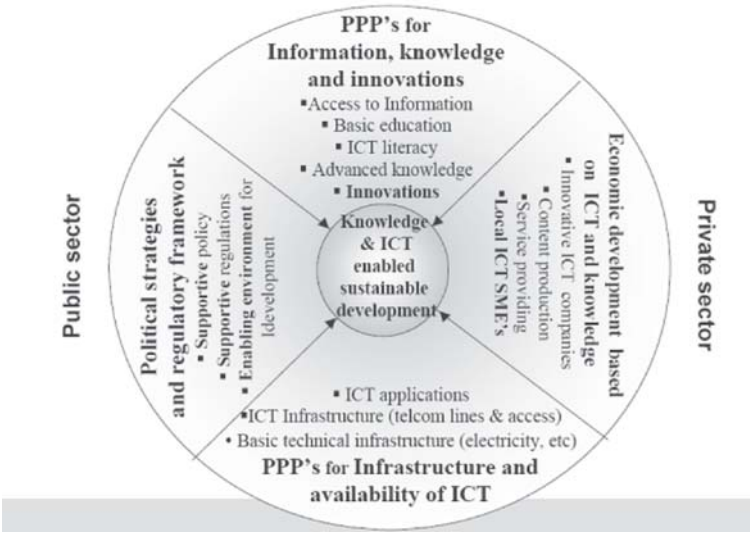
outlets throughout the country.

At the same time, a national campaign should be launched to develop low-cost computers for education that can be introduced into existing schools on a very large scale. A tie-up may be possible with major international computer manufacturers to provide long-term credit for this investment, as it will serve as a model for other countries and expand the world market for computer for education.

3. PRIORITIES IN POLICY – THE ROLE OF GOVERNMENT

The general principle that institutions should act on their comparative strengths, suggests that governments should focus on those responsibilities that the private sector is unlikely to shoulder, or not able to shoulder well. That is, governments should concentrate on activities whose spillover effects (externalities) are especially important that have clear public-good characteristics, or that address distributional concerns. Public action is important in narrowing knowledge-gaps and addressing information-related problems. So, the first step is to:

Formulate a National Strategy to Narrow the Knowledge-Gaps: The opportunities for countries and companies to move to better practice — for narrowing the knowledge-gaps — within and between countries — are nothing short of stupendous, and they apply not just to industry but across the entire economy. Grasping those opportunities requires openness to outside ideas. It also requires the right incentives and institutions, and it requires strong local efforts to acquire, adapt, and use knowledge effectively. Strategies to bridge knowledge-gaps should focus on three issues:



Development Policy Framework for Knowledge-based society

i. What policies foster the acquisition of knowledge?
ii. What policies enhance a country's learning-capacities? &
iii. What policies improve the effectiveness of communications and reduce the costs?

As countries search for the answers, competing priorities will vie for attention and resources, often posing explicit dilemmas and tradeoffs: Should countries acquire knowledge abroad or create it at home? Should educational systems extend basic literacy at the expense of investment in tertiary-education? Often the issue is a balance, and the balance shifts with a country's stage of development and its circumstances.

Tap Global Knowledge and Create Local Knowledge: Acquiring knowledge involves a combination of tapping knowledge from abroad as well as creating knowledge at home. Because no country can create all the knowledge it needs, learning from others is therefore a critical component of a successful strategy for all countries, even the more technologically advanced. Low-income economies must also build the capacity to adapt imported knowledge and to create knowledge that cannot be obtained internationally. The precise approach will vary according to a country's situation.

Some newly industrializing economies in Asia have increased up their investment in original research and development, even as they continue to learn from abroad. Some low-income economies find that they learn most effectively from the middle-income economies. While some economies in transition from central planning, given their already high educational attainment, continue to pursue advanced basic research, even as they catch up on manufacturing techniques.

To build their knowledge base, developing countries should explore all the available means of acquiring knowledge from abroad and creating it locally. They should:

- Find new and better ways of producing goods and services, through trade—ever more important as the structure of trade shifts from commodities and simple manufactured goods to increasingly knowledge-intensive products
- Work with foreign direct investors that are leaders in innovation, spurring domestic producers to try to match best-practice and to tap potential knowledge-spillovers
- Get access to new proprietary technical knowledge, through technology licensing
- Stimulate domestic innovation and get access to global knowledge, through establishing laws and institutions for the protection of intellectual property-rights
- Attract back those talented people who have studied or worked abroad, and
- Promote domestic R&D, to make it more responsive to the market.

Trade: Openness to trade is essential. One of the main reasons the East Asian economies were able to grow so fast, for so long, was their ability to build strong links

with world-markets and to draw upon the technology flowing through those markets. They did this with policies ranging from trade liberalization to export promotion, some of which offset protectionist biases favoring domestic industries.

For domestic producers, to be competitive internationally, export promotion and diversification are also valuable. They must meet international standards and adopt up-to-date technology. Exporters also receive much technical information from buyers and suppliers, and importers get access to knowledge embodied in new goods and services. But for trade to expand, countries also need good standards, measurement, testing, and quality control systems, so that domestic products and services can compete in the global market.

Foreign Direct Investment: Countries with more open trade-regimes are likely to attract competitive, outward-oriented foreign investment, which brings efficient technology and management into the economy. Hong Kong (China), Indonesia, Malaysia, Singapore, Taiwan (China), and Thailand, have been particularly welcoming, and their growth spurts were closely linked to surges in foreign direct investment. In contrast, Sub-Saharan Africa has been less open to foreign trade and investment. Partly as a result, the region has attracted only about 1 percent of worldwide foreign direct investment to developing countries, and it has lagged behind other regions in acquiring knowledge and in achieving economic growth. To attract foreign investment, developing countries also need appropriate infrastructure — both "hard" infrastructure, such as transport and communications, and "soft," institutional infrastructure, such as effective legal, financial, and educational systems.

Technology Licensing: Technology licensing has become increasingly important, since new knowledge is expanding rapidly. Governments can facilitate the inflow of such knowledge by removing restrictions on access to technology-licensing or the restrictions terms of such contracts. Instead, by encouraging creation of domestic information-centers, where local firms can obtain information on foreign-technology, countries can reduce their firms' disadvantages in negotiations for licensing.

Intellectual Property Rights: As the world moves toward a knowledge-based economy, producers of knowledge are seeking stronger enforcement of intellectual property rights — and that has mixed effects on the production of new knowledge and the closing of knowledge-gaps. Well designed intellectual property-rights regimes, try to balance the private incentives for the creation of knowledge against the social benefits from its dissemination. This balance is difficult to achieve, because most of the producers of knowledge reside in industrial countries. But adequate intellectual property-rights are necessary if countries are to get access to foreign technology through foreign direct investment and technology-transfers. They are also important in stimulating the domestic creation of knowledge, which in many developing countries will grow as they strengthen their human and technological capabilities.

How should developing countries respond to the trend toward intellectual property-

rights? The answer is twofold. First, they should negotiate internationally for intellectual property-rights regimes that give adequate consideration to their urgent need to narrow the knowledge gap, — while maintaining incentives for knowledge-producers everywhere, to continue their creative activity. Furthermore, as new technological developments bring in new issues for negotiation—biotechnology and information technologies, for instances. Developing countries will need to keep up with these trends and represent their own interests. Second, developing countries should establish and enforce intellectual property rights standards that comply with international practice, because adhering to those standards is necessary to get access to foreign technology through foreign direct investment and technology-transfer, and to get access to foreign markets through trade.

Governments of Developing countries can also continue efforts to negotiate for definitions of intellectual property-rights that recognize the value of indigenous knowledge and reward those who create and preserve it. For example, in 1990 world-sales of modern medicines derived from plants discovered by indigenous peoples were estimated at $43 billion. Yet only a tiny fraction of this amount went to the people and groups who had preserved the traditional knowledge of these medicinal plants, or to the countries where the plants were found. Developing countries thus, need to increase their capability to negotiate better terms with foreign firms who would profit from this knowledge. To do so, they must participate actively in evolving international agreements on intellectual property-rights and biodiversity.

People: A final important channel for the acquisition of knowledge from abroad is expatriate nationals. Today more than a million students from developing countries are enrolled in higher education programs abroad, and many will stay where they have studied. Many of the best-trained at home, finding few opportunities to use their new knowledge in their own countries, will also end up emigrating.

This continuing brain-drain has led some developing economies to establish programs to encourage expatriates to return. Korea, Taiwan, China, and Pakistan offered well-trained expatriates good job-opportunities and strong financial and tax-incentives to return home to teach or work. China, India, and Taiwan have tapped the expertise of their overseas nationals, without bringing them back, by offering special opportunities for trade and investment.

Are all modes of knowledge transfer equally conducive to domestic learning? Probably not. The most appropriate form of know-how is that which matches the sophistication of the technology with domestic capabilities. Licensing coupled with a strong domestic technological effort, may be appropriate for firms in a newly industrializing economy, whereas foreign direct investment may be a more suitable approach for a lower-income economy. The East Asian economies drew on the full range of possibilities, the precise mix differing with the base of capabilities and the technological vision of the government. Their experience shows that there is more than one solution, and that the most effective strategies make the most of all available channels for tapping global

knowledge, as well as creating it locally.

Creating Knowledge at Home: Developing countries, in addition to taking advantage of the large global stock of knowledge, should develop the capability to create knowledge at home. Even in manufacturing, knowledge from other countries must often be adapted to differences in climate, consumer tastes, and availability of complementary inputs. And some types of knowledge must be built from the ground upwards. Examples include knowledge of the local environment and social customs, often vital for effective policy. For these and other reasons, a balanced strategy for narrowing knowledge gaps must include the capacity to create locally the knowledge that cannot be obtained from abroad.

Governments can encourage research, either directly through public R&D or indirectly through incentives for private R&D. Direct government R&D includes that financed at universities, government research institutes, science parks, and research-oriented graduate schools. Indirect support for R&D includes preferential finance, tax concessions, matching grants, and the promotion of national R&D projects. For most developing countries, however, local research should focus on essential needs. Maintaining core strengths in basic science and technology may be necessary not only to maintain access to the global pool of knowledge but also to adapt that knowledge to local uses.

Many public research institutions lack either information on the needs of the productive sector or incentives to respond to those needs. That is why Brazil, China, India, Korea, and Mexico have launched vast programs to reform their public R&D laboratories and focus them on the needs of the productive sector. The measures include restructuring the labs so they operate like corporations, capping the government's contribution to their budgets, to provide incentives for researchers to seek corporate-sponsorship, improving the pay and recognition of researchers, and giving firms direct incentives to place research-contracts with them.

Only a few developing economies like Korea, Singapore, Taiwan, China, have provided the right incentives for significant private R&D, and allowed their publicly funded R&D institutes to focus on more basic pre-commercial research. But continuing strong governmental support is essential in some other crucial areas, such as research to adapt international advances in agriculture and health, to a country's circumstances.

Increase People's Capabilities to Absorb Knowledge: An effective strategy to narrow knowledge gaps must include measures to increase people's capacity to use knowledge. Ensuring universal access to basic education is the crucial first step, but it is not enough. Countries must also ensure that they have enough highly trained personnel, including engineers and scientists. This requires strong secondary schools and universities, especially for engineering and science. And it means providing opportunities for lifelong learning after students complete their formal education. To

meet these needs with a limited budget, all countries, especially the poorest, must obtain the best possible return for their investment in education.

To address these problems, governments should consider the following possibilities:

- Decentralize education to give more power to those with the most information about educational needs and how to meet them: students, parents, teachers, and local school administrators.
- Focus public resources on those who need them most, for example by giving subsidies to the poor and to females.
- Provide support for higher education, especially in the sciences and engineering, while ensuring access for the poor, and
- Use new learning-technologies to improve the quality of education and to broaden access.

Decentralize to Give Power to those with the Most Information: Achieving educational goals often does not mean spending more, but rather improving the quality and delivery of education. Although increasing spending to reduce class size, for example, would almost surely improve educational quality. Qualitative improvements are often possible even within existing budgets, by simply increasing efficiency and reforming the way education is provided.

Education-systems confront complex information-related problems, and addressing these problems can help improve educational quality. One way to do this is to move from a top-down to a more client-driven approach. Placing power in the hands of those closest to the education-process. Most of the experiments under way, throughout the developing world, offer a great opportunity to learn what is most suitable. For example, in El Salvador, teacher absenteeism has declined in community-managed schools, even in the poorest communities, because parents closely monitor performances of teachers.

Focus Public Resources on those Who Need them Most: Despite the high private returns to education, many people cannot take advantage of educational opportunities because they cannot pay the cost. Education requires considerable private resources, even for education that is "free" in the sense that no fees are charged. Time spent in school is time not spent on other tasks: working for a wage or in a family enterprise, or caring for younger siblings, a task that often falls to girls. For the poor, these opportunity costs may make education unaffordable, especially when access to credit is lacking. Governments can alleviate these problems through a variety of mechanisms: higher subsidies to schools in poorer areas, direct stipends for disadvantaged students (like those recently provided to girls in Bangladesh), and student loans for higher education.

Support Tertiary Education, Especially in Engineering and the Sciences: Many low-income economies have programs of tertiary-education that prepare workers for

scarce civil-service positions, but do not improve technical skills. Often it is more effective to focus public resources on the preparation of engineers and scientists, capable of absorbing and adapting advanced technology. Korea achieved universal primary-enrollment before its economic takeoff, and it moved quickly to expand tertiary-education and train its own scientists and engineers. Today its enrollment-shares in mathematics, computer science, and engineering are similar to those in many OECD countries. Strengthening tertiary-education need not require more spendings by government, especially in the long-run. Because advanced training confers significant benefits on those who receive it, governments can often increase tuition charges, while still ensuring access for low-income students, for example through expanded student-loan programs.

The transition-economies face particular problems. They need to improve the content, delivery, and funding of education to respond to market-demands and tight budgets, especially in fields of science and engineering. Some of the transition-economies that had first-rated scientific and engineering establishments, are now threatened by underfunding and a brain-drain. Maintaining quality and redirecting research and teaching to reflect the new reality will prove to be a challenge.

Use New Learning Technologies to Improve Quality and Broaden Access: New technology for teacher training and distance education has greatly increased the opportunities and reduced the cost of adult learning outside traditional campus settings. In China, half of the 92,000 students who graduate with degrees in engineering and technology each year, are taught through distance-learning, provided by traditional universities. The African Virtual University is trying to increase university-enrollments and improve the quality and relevance of instruction in business, science, and engineering, throughout the Sub-Saharan region. So far it has installed 27 satellite-receiver terminals, and to compensate for the dearth of scientific journals in African universities it has developed a digital library.

In sum, an effective educational system is critical to increasing people's capacity to absorb knowledge. Reforming educational systems to achieve this goal involves more than simply spending more from the public purse. Governments must apply their resources to the array of institutions and activities associated with lifelong learning: preschool programs, basic formal schooling, higher formal schooling, formal training programs, on-the-job learning, information-dissemination programs, and informal education.

The most effective public actions are that focus directly on the information-related problems, which underlies market-failures, or that addresses distributional concerns.

Build the Capacity for People to Communicate: The new information and communications technologies (ICTs), let people share knowledge today at an ever more affordable cost. The potential is thus great for developing countries to take advantage of the new technologies, to upgrade education systems, improve policy

formation and execution, and widen the range of new opportunities for businesses.

To realize this potential, countries need to make effective use of information-technologies, which is a key thrust of their national developmental strategies, just as Malaysia has done. Countries should:

i. Ensure competition and appropriate regulation, to unleash private-initiative to provide communications infrastructure and services, and expand the use of new technologies; and
ii. Ensure that services are extended to remote areas and to poor, by moving away from traditional cross-subsidy schemes, and working instead in partnership with the private-sector or end-users to determine the required governmental support.

Monitor and Enforce Performance: Ensuring that organizations and individuals live up to their promises is a problem in all societies, but tends to be especially severe in the weak institutional environments that characterize many developing countries. Three imperatives for policy are to:

i. Develop a strong legal and judicial system, but
ii. Create incentives to minimize recourse to it, and
iii. Explore innovative, alternative approaches for enforcement.

Recognize the Persistence of Knowledge-Gaps and Information-Related Problems: No matter what governments do, knowledge-gaps and information-related failures will persist. Even countries that pursue an aggressive, knowledge-based, developmental strategy, will not be free of these problems. Policy-makers have to live with imperfections:

- In many instances, policy makers have to make key-decisions in the absence of complete knowledge.
- In all instances, they must keep in mind that even policies unrelated to knowledge and information will play out in an economy, subject to information failures — and thus, to market failures.

Policy-Making Amid Persistent Knowledge-Gaps: Some of the positive spillovers from education — educated farmers show the way for uneducated ones, educated mothers have healthier children, and so on. In other instances, actions that benefit a firm or an individual have negative spillovers — water pollution from firms and air pollution from automobiles are prime examples.

An important role of government is to maximize well-being by altering incentives to take these spillovers into account, for example by providing education-stipends and taxing water-pollution and gasoline-consumption. But because spill-overs are difficult to measure, policymakers can seldom know their precise magnitude. This is not to say

that governments should ignore them. The appropriate course is trial and error, using the tools at government's disposal to re-adjust incentives to achieve socially desirable outcomes.

The need for an effective policy-response is greatest when action—or inaction—risks irreversible damage to human well-being. We do not know precisely the future impact of today's carbon-emissions on global warming. But given the risks, it is prudent to err on the side of caution and to restrict emissions in the most cost-effective way possible. Similarly, we cannot know in advance, which salamander or orchid contains a cure for cancer, or how diverse species support one another and maintain the entire web of life. So the prudent course is to preserve fragile and unique ecosystems, even when this means forgoing short-term economic gains from converting forests into pasture, or wetlands into ports. In other areas, such as health care, failure to act may have irreversible consequences. Although measures of the long-term effects of childhood malnutrition are less then perfect, we know these effects are likely to be permanent, and that prudent governments should ensure that every child has enough to eat.

In these and other cases, policy-makers are also hampered by lack of knowledge about the impact of specific policies.

Indeed, most policies, even those that do not involve spillovers or irreversible consequences, must be adopted in the midst of persistent knowledge-gaps. In part, this dilemma stems from imperfect knowledge of human-nature — people respond to policies in unpredictable ways. The problem is worse in developing countries, where the capacity to design and implement policies is poorly developed, and where the technology for recording and analyzing information about people's responses is often lacking.

There are many examples where the availability of information to the government, is critical to the implementation of programs of government. For example, unless government can effectively monitor sales, it cannot impose a sales tax.

4. PROMOTING INNOVATION IN DEVELOPING COUNTRIES

The climates for innovation in developing countries are, by nature, problematic, characterized by poor conditions of business and governance, low-educational levels, and mediocre infrastructure. This raises particular challenges for the promotion of innovation. The latter should be understood as the diffusion of technologies - - and related practices, which are new to a given context (not in absolute terms). What matters first is to provide the necessary package of support – technical, financial, commercial, legal, and so on – with flexible, autonomous agencies adapting their support and operations to the different types of concerned enterprises. Facilitating and responding to the emergence of grass-root needs at the local level is also essential. Support to entrepreneurs and local communities should be primarily provided in matching grant forms to facilitate the mobilization of local resources and ownership.

It is of primary importance to pay the greatest attention to country specificities, not only in terms of development level, size, and specialization, but also in terms of administrative and cultural traditions. At the global level, major issues also need to be considered and dealt with by appropriate incentives and regulations, the role of foreign direct-investment in developing countries' technological development, conditions of patenting and licensing of technologies, the North-South research asymmetry, and brain-drain needs.

Thrust Areas for Developing Countries: Out of a long list of new and existing technologies that can contribute to the economic growth of a country, four technologies have been shown to have the highest combined impact on the economic transformation. These are Information and Communication Technologies (ICT), Biotechnology, Nanotechnology and New Materials.

Information and Communication Technologies (ICT): ICT is a powerful enabler for development by facilitating access to information and knowledge resources in a cost effective manner and its ability to improve the basic services such as health and education. Developing countries need to promote the role of ICT for integration into the global economy in addition to enhancing communication, access and sharing of information. Effective deployment of ICT can also lead to the creation of business opportunities and jobs and it can have a profound effect on existing sectors. For ICT to be an effective tool for development there needs to be extensive and affordable access as well as sufficient human and technical capability developed through comprehensive national ICT strategies. These measures will reduce the existing economic and social inequalities between the developing and the developed countries. Through global, regional and local level programs developing countries should establish infrastructures, enhance connectivity for better access to knowledge, which will ultimately create jobs, promote commerce, trade exchanges, education and training.

ICT has already had an enormous impact on health care in developing countries by providing the opportunity of telemedicine for remote consultations and diagnosis and access to essential medical information. Through the new and traditional means, ICT disseminates information on health care and disease prevention to the masses. In the fight against HIV/AIDS, malaria and other diseases it is an effective tool for patient education, disease monitoring and management and drug distribution which is a part of the action plan of the Millennium Development Goals. ICT also facilitates the participation of the population in protecting the environment through networking and exchange of information. It provides the necessary means for simulating and analyzing the environmental processes for predicting the natural disasters. A large volume of data are available to the developing world in the open literature generated mainly by the industrialized countries which should be used in making policy decisions and by developing systems and skills necessary for utilizing this knowledge. Capacity building and exchange of information at all levels is the key to making economic progress.

Biotechnology: Biotechnology can also play an effective role in meeting the development challenges of the developing countries, particularly in the health related areas. Ten fields of biotechnology have been recognized that can contribute in improving the health care within a short span of time. These include molecular diagnostics, recombinant vaccines, vaccine and drug delivery, bioremediation, sequencing pathogen genomes, protection against sexually transmitted diseases, bioinformatics, nutritionally enriched genetically modified crops, recombinant therapeutic proteins and combinatorial chemistry. These technologies are powerful tools for reducing child mortality, improving maternal health, combating HIV/AIDS, malaria and other diseases, which are the three important Millennium Development Goals (MDGs). Bioremediation would not only help in improving the health-care services but also in cleaning the environment by using biological agents like bacteria and plants. Bioinformatics enables the analysis of large volume of biological data which is generated through R & D for utilization in development programs. Many educational sites are available free on the internet, along with bioinformatics databases, which can be accessed by scientists for conducting research in several fields of biotechnology. Six universities are offering free web-based courses in bioinformatics for the benefit of workers who have no other training ground available to them.

The current applications of biotechnology are mainly in the fields of agriculture and medicine, allowing the production of new and improved foods and the development of virus-resistant crop-plants. New and more effective antibiotics, vaccines for malaria, and improved ways of producing insulin are now possible. Diagnostic tests for detecting serious diseases have been developed, as well as, ways of detecting and treating AIDS. Biotechnology is also being applied in the areas of pollution control, mining and energy production. Genetically engineered micro-organisms and plants are used to clean up toxic wastes from industrial production and oil-spills. Biotechnology applications have also been introduced into the forestry and aquaculture-industries. These strategies offer hope for conservation biologists. Genetic methods can be used to identify particular populations of endangered species. Overall, biotechnology has the capability of improving the quality of life for people on this planet.

Nanotechnology: Nanotechnology is, broadly speaking, the art and science of manipulating and rearranging individual atoms and molecules to create useful materials, devices, and systems which find applications in water treatment and remediation, energy storage , production , disease diagnosis and screening, drug-delivery system, health monitoring , air pollution , food processing and storage, pest-detection and control and in enhancement of agricultural productivity. Nano-porous materials can be employed for slow release of fertilizer for plants and nutrients and drugs for live stock. Nano-membranes and nano-clays can purify, detoxify and desalinate water. This technology is particularly important for developing world, because it involves little labour, land or maintenance, it is highly productive and inexpensive and requires only modest amounts of materials and energy. It can

contribute new tools for sustainable development and strengthen the existing technology. Significant activity in this field is already taking place in developing countries like China, India, Korea and Brazil. Applications of nano technology in solar cells, fuel-cells and novel hydrogen storage-systems, based on nano-structured materials can provide cleaner and environmental-friendly energy-systems. Nano-catalysts can convert the waste-products of non-renewable energy-sources to materials that are not damaging to the environment and human-health. Nano-biotechnology can also help in enhancing biodiversity.

Materials, both natural and man-made are playing an increasingly important role in technological development. New technologies require materials of high performance, which need to be developed through an intensive R&D effort. Investment in education and research in materials science should therefore, occupy high priority on the developmental agenda of the developing countries. Materials are playing a crucial role in bringing about the technological change and are essential for achieving the Goals. For example, the development of low-cost building-materials could provide shelter to the many homeless and also help in setting up schools and hospitals in remote areas where the conventional construction-materials are either too expensive or not available. New materials based on ceramics, metals, alloys and polymers, called 'Advanced Materials', have superior properties. Use of new and advanced materials will all contribute to the economic development.

Science, technology, and innovative education can be promoted through the participation of universities, research institutes, S&T societies, private sector and the non-government organizations. Above all, the determination of governments to undergo transformation to a knowledge-based economy must be reflected in its policies by investment in human-resource development, universities and other academic institutions. International partnerships and linkages are also an important aspect of technological development in developing countries. Incentives should be provided to encourage such partnerships. Partnerships with other institutions, at the national or regional level, could be of great benefit. Many academics of developing country are benefiting from institutional partnerships with universities and R&D institutes abroad. Research-partnerships across academic, industry, and government-institutions help reduce knowledge-gaps, especially in small and medium-size enterprises, which often lack adequate R&D facilities.

5. APPROPRIATE STRATEGIES AT THE NATIONAL LEVEL

Innovation ambitions and policies have to be adapted to levels of development and educational bases. Differences in institutional capabilities (strong, limited, weak) need also to be taken in consideration. It is possible to outline a specific policy agenda for different types of configurations, as summarized in Table - 1.

Support should be initially focused on most promising regions and industries in order to build a climate of self-confidence through success stories, and then facilitate a

broader reform process.

Low-Income Countries: In low-income countries, where the institutional capabilities are limited, policies should focus on investment in technological infrastructure, and demonstrate operations of "basic" innovations, which can contribute to improvements in welfare, education, and agriculture. This is important for establishing a dynamic technology-sector and for promoting technology-led development that goes beyond meeting the need to survive. An example is provided by Uganda, which began with a good investment-promotion agency, used specific advantages at a low-technology level (e.g. with cultivating flowers and exporting them in European markets), made appropriate reforms in the education-system at all levels, and benefited from coherent support from donors. Thus, Uganda has gradually been able to build a sustainable path toward development.

Where institutional capabilities are relatively strong, there is the possibility for a more comprehensive, dynamic and structured policy. Vietnam set an example strongly articulated policy was put in place, to develop new cultures, taking advantages of the climatic features of the countries. In providing the necessary technical support, organizing transport and logistics for exports. On the high-tech front, vigorous actions were taken for developing a competitive software-industry in selected niches, in building on state-owned enterprises and making good use of procurements by government. Meanwhile other reforms were gradually implemented in many other key-areas, such as, education, finance or trade, creating a broader environment more conducive to innovation.

Medium-Income Countries: For medium-income countries with no S&T capability, but with some institutional capacity, policies can focus on fostering the development of brand new activities world class IT oriented services. A good example is provided by Dubai, which by attracting both foreign-investors and an educated labor-force (notably from the Arab countries and from India), has been able to establish from scratch a set of Internet and media-cities. Key for this was the vision and drive provided by the leadership and the establishment of powerful agencies, able to act on all necessary fronts.

For medium-income countries, with a relatively strong S&T work-force but low institutional capability (Russia, Argentina), the road ahead seems to be through the development of autonomous innovative promotion-institutions, managed as private-sector organizations, and focused on establishing sustainable clusters of innovative-firms. A major problem faced by such countries is, resistance to reforms, and difficulties in transforming existing R&D organizations and revitalizing the entire R&D system that is in decay. Thus, there is a need for marshalling entrepreneurial capabilities around existing technological and scientific assets, and drawing on the support provided by bodies, which are agile and not caught in the government-machinery.

Table - 1: Innovation-Systems and Policy-Agendas (Y. Kuznetzov)

Level of Institutional and Human Capital Capabilities	**Strong Institutions** (litmus test: business R&D dominate R&D budget) Decision-making horizon: long-term	**Limited Institutional capabilities** (litmus test: large stock of export-driven FDI exists yet national innovation system is virtually irrelevant for business) Decision-making horizon: medium-term	**Weak or fragile institutions** (little state activism is possible/ desirable) (litmus test: investment climate is poor and volatile) Decision-making horizon: short-term; survival
Low-Level S&T Capabilities Technology-adoption		**Exports as a springboard' agenda:** Developing non-traditional exports as entry point for institutional and technology development Central America (with the exception of Costa Rica) Traditional urban and rural economies in India and China Korea in the 60's Mexico in the 70's Vietnam, Mauritius	**Technology basics agenda:** Creation of demonstration effect to show that innovation does matter, in particular in health, education, agriculture and crafts Most of Sub-Saharan Africa Most Central Asian states
Medium-Level S&T Capabilities Technology's Adaptation	'Turning point' agenda: a need for transition from global sourcing to proprietary technology		
	Increase in R&D investments Korea, Ireland in the 90's Malaysia India (IT clusters)	Increase in business-related R&D through recombination of S&T capabilities EU accession countries Chile, China, Mexico, Brazil, Turkey, South Africa & S. Korea in the 70's and 80's	
High-Level S&T Capabilities Technology-Creation	Innovation leaders agenda: Development of proprietary technology through promotion of innovation clusters (Korea, Singapore, Taiwan Finland & Israel)	'Turning point' agenda: Increase in business R&D through recombination of S&T capabilities	'Embedded autonomy' agenda: Creating a diversity of autonomous business-led innovation organizations (Foundation Chile agenda) (Argentina, Russia, Ukraine, Belarus, Armenia & Chile in the 70's)

Lastly, in medium-income countries with a strong S&T capability and a relatively good institutional capability (such as Chile, Poland), there is a need to improve the science-base. Public investment can be recommended as a means to this end, provided that the business-environment is good enough for private-sector to invest significantly in R&D. The way to make the S&T and educational structures more responsive to innovation-needs of the surrounding business-communities, lies in the change of funding mechanisms.

High-Income Countries: High-income countries are in many ways, confronted by issues similar to those of medium-income countries. These countries have to climb up to a higher level of indigenous innovation-performance. Ireland and S. Korea have been confronted, each in their own way, by this challenge. Ireland, which built its innovation-system largely on FDI, attracted by strong incentives and a high-quality educational infrastructure, is addressing this challenge by seeking to strengthen its research-base through massive investment, notably through a recently established Irish Science Foundation. S. Korea, which had rooted its economic growth and industrial development in large conglomerates (Chaebols), is seeking to enlarge its science-base and diversify its economic structures through a vigorous innovation-led regional policy-approach.

Multi-level Situations: Problems become even more complex when considering large countries, which encompass different levels of development. Typical examples include, China, India, Brazil and Mexico. Here, the key is to exploit dynamic regions of different levels of development and with differentiated comparative-advantages.

Main Messages: A few key-ideas can be retained from the above discussion on promoting innovation:

- Conceive innovation in a broad manner, namely as something new to a given context; the notion then becomes fully relevant to developing countries, even the poorest ones, and applies to all walks of life, from the most basic welfare improvements to the building of vibrant competitive-industries.
- Adapt ambitious and innovating strategies based on a country's technological and institutional capability, by building on their strengths and specifications (including traditional forms of knowledge and governance) and, where possible, by correcting identified weaknesses.
- Provide support in the form of integrated packages; this applies to all levels at the micro-level for upgrading enterprise; at the meso-level for the development of specific regions or industries; at the macro-level in the building of climate conducive to innovation (which requires a good business environment, an educated population and efficient infrastructure).
- Establish efficient institutions and organizations, operating with sufficient autonomy and in a flexible manner for delivering needed support to innovators (legal, financial & technical).
- Work on specific promising regions and sectors for stimulating dynamics of

change and reforms through success stories.

- Act at the global level for increasing innovation-opportunities for developing countries in remedying problematic aspects of current patent-regimes, facilitating international research-cooperation and compensating brain-drain processes. Relevant actions may concern both the developing world and the developed one.

6. EXPLOITING STRENGTHS AND OPPORTUNITIES – SUMMARY OF RECOMMENDATIONS

Pakistan and other developing countries can do much more to leverage its strengths in today's knowledge-based global economy. Notably:

Improving the Climate for Investment

- Promote macro-economic stability; competition; good regulatory-policies; legal rules and procedures conducive to entrepreneurship and risk-taking;
- Simplify and expedite procedures for entry and exit of firms;
- Reduce tariff and non-tariff barriers to trade; &
- Improve physical infrastructure.

Grooming World-Class Knowledge-Workers

- Expand access to primary and secondary education and improve quality and relevance
- Allow the private-sector to fill the burgeoning demand for higher education, by relaxing bureaucratic hurdles and putting in place better accreditation-systems for providers of private education and training.
- Increase university-industry partnerships, in order to translate research into applications that can yield economic value.
- Develop life-long learning-programs to meet the learning needs of all, both within and outside the school-system, including using distance-learning technologies to expand access to, and the quality of formal education and life-long training programs.

Promoting Innovation

- Tap into the growing stock of global knowledge, including removing excessive regulations on imports and foreign-direct investment;
- Allow national research institutes to collaborate with domestic and foreign firms, forging closer links with industry to create applications that meet the needs of the economy;
- Create an attractive environment to stimulate private R&D investments, including tax and other incentives; &
- Create a national fund to support grassroots innovators, to stimulate innovations for the needs of the poor, and to convert innovations into viable business-plans, especially for job-creation.

Creating a Center of Excellence for Information and Communication Technology (ICTs)

- Increase access to ICTs by increasing competition and reducing import tariffs
- Move up the value-chain in IT, by developing high-value products through R&D;
- Further develop and scale up ICT applications, such as community-radios, fixed/mobile phones, smart cards, Internet and satellite television, to bring the benefits of connectivity to rural communities; &
- Share successful applications of ICT, for example, in e-government among different Indian states.

7. CONCLUSIONS

Recent developmental thinking has been based on the assumption that markets work well enough to ensure development and alleviate poverty. Our growing understanding of information constraints suggests that markets alone are often inadequate; societies also require policies and institutions to facilitate the acquisition, adaptation, and dissemination of knowledge, and to mitigate information-related failures, especially as they affect the poor. This view implies an expanded mandate for public action.

Yet governments, like markets, are hampered by informational failures. In deciding which problems to address, policymakers balance the size of the information-problem and the resulting market-failure against the capacity of the government to improve the situation. The appropriate course of action will vary, depending on the circumstances. In all countries, however, openness to learning, recognition that there is much we do not know, and a willingness to make midcourse adjustments, will enhance the prospects of success.

We began by comparing knowledge to light. When we look back in 25 years on progress in development in the first quarter of the 21st century, which countries will stand out? It will surely be those that have mastered the acquisition of knowledge, increased the capacity to absorb it, and improved the means of communication for all their citizens. It will be those that have also found ways around information-failures and improved the effectiveness of markets. It will thus, be those that have extended the power and reach of knowledge to enlighten the lives of people everywhere.

KNOWLEDGE AND SUSTAINABLE DEVELOPMENT

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I. INTRODUCTORY SURVEY

Knowledge is vital for the social, cultural and economic development of a nation. The same is also true for sustainable development. Mankind has been fortunate enough to amass a huge treasure of knowledge since the beginning of civilization. However, the last three centuries have witnessed unprecedented increase in the whole body of knowledge, particularly in science and technology. Rapid progress was made in chemical sciences in the eighteenth and nineteenth centuries, whereas Physics and Biology made fast moves in both the nineteenth and twentieth century. With deeper understanding of these basic sciences, new disciplines, like biochemistry, chemical engineering, space sciences, biotechnology, genetic-engineering, medical technologies, nanotechnology and nuclear-engineering emerged on the world scene, which played an undisputedly important role in the socio-economic and political evolution of mankind during the last hundred years. Side by side, the progress in science and technology, new thoughts in philosophy, psychology, sociology, economics, morality and ethics also appeared on the world's stage and largely helped in shaping the contemporary mind-set. The interactive outcome of these two aspects of knowledge and its consequent impact on the life of mankind was expected to be overwhelmingly beneficial in the long run. However, and surprisingly enough, this impact has not been able to create a pleasant global paradigm. Today one finds oneself living in a world full of all kinds of divides, conflicts, miseries uncertainties and insecurities. It appears as if man's vices have over-powered the virtues of knowledge.

Does mankind really see a better future for itself? Will the economically marginalized people of the world have a chance to put themselves on the road to development and progress? And will there be a peaceful and economically prosperous world any time soon during the twenty first century? These are the questions that stir the minds and souls of every person living today. No doubt, the answer to all these questions lies in the truth that peace and prosperity, very largely, depend upon the economic strength of the nations governed by well understood norms of morality and ethical responsibilities of the individuals. These essential requirements for a better future can only be based on a sound foundation of universal knowledge, which has to be valued much more sincerely by the underdeveloped world than it is hypocritically done today.

Science and Technology (S&T) has been the main engine of economic development in the recent past and will, no doubt, remain the main driving force for the future prosperity. The governments and policy-makers have no choice but to realize the

importance of this reality. One of the major impediments to progress has been the persistent indifference of the underdeveloped nations towards science and technology. The poor societies need to exert more pressure on their governments to sensitize them towards the stark reality that, without technological advancement, they will continue to remain poor and subject to indignities. Collaboration, trust in each other and faith in their future are essential prerequisites to step on the road to development. This is exactly what the Commission on Science and Technology for Sustainable Development in the South (COMSATS) has been striving for during the past one and a half decade. One of its major objectives is to sensitize the governments of its twenty one developing Member States, located in the continents of Latin America, Asia and Africa, to realize the importance of science and technology for socio-economic progress of any magnitude. On similar lines, the Organization of Islamic Conference's Standing Committee on Scientific and Technological Cooperation (COMSTECH) and the Islamic Educational, Scientific and Cultural Organization (ISESCO) are working for the collective progress of science and technology in the Islamic Countries. On the United Nations platform, the UN Educational, Scientific and Cultural Organization (UNESCO) has been trying for several decades to create awareness among the developing countries about the effective role that education, science and technology can play to pull the poor countries out of backwardness and to show them the path towards development. **The task is difficult and the process is slow.** It is a sad fact that so far the governments and the other stakeholders have not been able to convince themselves to create a strong will to promote the cause of science and technology with full commitment and energy. Once the existing inertia of the present mindset of the developing societies is overcome, the era of opportunities will unfold itself and the golden journey to richness and prosperity can begin.

Knowledge-starved societies suffer from another devastating affliction, which manifests itself in the form of incompetencies and inadequacy of capacities. Coupled with inappropriate ethical and moral tendencies, the poor societies, more often not than fall into the abyss of corruption and other social vices. This paralyses the nations' ability to prepare a clear mission of their developmental goals, to plan the correct course of their welfare-activities and to muster support of others for collective action. *Cultural and moral dimensions, thus, become extremely important for the beneficial applications of science and technology for the desired and tangible outcomes needed to help the pursuit of economic-development.*

Mankind has seen a variety of geo-political and socio-economic ups and downs during the twentieth century. Emergence of Communism, its rise and demise, political decolonization of the third world, accompanied by massive siphoning off of the wealth to the West, commercial exploitation of oil and other energy reserves, two world-wars, dominance of multinational businesses, technological strides in communications and travel, multifold increases in computing capabilities, dramatic break-throughs in biology and genetics, space-experiments and several other social and technological factors have brought the people of the world together and have, at the same time, created a cultural melting-pot at the global level. The socio-economic, political and

technological hurricanes of the past century have, thus, been mainly responsible for the large gaps in prosperity and knowledge that the twenty-first century has inherited alongwith their painful consequences.

Despite the economic, cultural and security disparities, which evolved during the last century, the advent of the twenty-first century was welcomed by mankind with the hope of a better future. Slogans, such as, the "New World Order" and "Millennium Development Goals", etc., did impress the developing world and brought out new aspirations for economic well-being through strong collaboration between the poor and the rich societies. Though the efforts under the above mentioned initiatives are making progress, yet the pace of progress has been considerably slowed down by many unfortunate events, including the 9/11 catastrophe, which struck the world at the start of the new Millennium and changed entirely the concepts associated with the 'New World Order'. A new pattern of international relationship is emerging as a result of other events that followed 9/11. Consequently, poor and rich countries had to struggle hard to adjust to the new geo-political realities. The new world scenario for peace and security will redefine the parameters of economic cooperation between the developed and developing countries.

The new and emerging paradigm will most probably become more complex and intricate in the coming decades. The developing world will, therefore, need to make drastic readjustments in their policies and in their social mind sets to cope with the new, but difficult, realities. The developing countries will have to strengthen their knowledge-base seriously and will have to apply the strength of knowledge to their indigenous technological improvements and economic progress. How to achieve this crucial objective in the changed world scenario, is the fundamental question facing the majority of the developing nations. The answer to this question would come from the intellectual segments of the developing world, consisting of universities, think-tanks, public debates, NGO's, etc., and will also depend upon the political will and implementation capacities of the decision makers. This could also need a clear understanding of the expressions "knowledge" and "development", their mutual relationship and, above all, the new challenges that will have to be faced by the developing countries to put themselves on the path of prosperity during the twenty-first century. These aspects will be discussed in the following sections of this Article.

II. KNOWLEDGE

Defining Knowledge: The lexicographical definition of the word 'knowledge' is given as (a) "understanding" and (b) "everything that is known as an organized body of information" (Oxford Advanced Learner's Dictionary). Several other related definitions employing both philosophical and practical connotations exist but, for the simplicity of the present discourse, it seems appropriate to attach the attributes of "understanding" and "information" to the concept of knowledge. This will have closer links to disciplines, such as, basic and applied sciences, technology and engineering, social and ethical studies, philosophical and psychological concepts applicable to

mankind's every day life, and the relationship of these disciplines with economy, prosperity, security and peace. However, the overall definition of knowledge should not exclude the concept of possession of information, facts, ideas, truths and principles by individuals or groups of individuals. A more comprehensive analysis of knowledge from various perspectives can be found in the paper of Dick Stenmark, entitled "Information & Knowledge" (Proceedings, 35th Hawai Int.Conf. on System Sciences, 2002, pp. 1-10).

Power of Knowledge: Knowledge is power. Consequently whoever possesses knowledge will possess power. Knowledge is like light; it is intangible and travels easily, enlightening the lives of everyone. Power, enlightenment, prosperity, dignity and happiness comes with knowledge. Hatred, bias, fanaticism and closed minds prevent the traveling and infusion of knowledge, like opaque objects that stop the travel of light. Education and diffusion of information are essential pillars of knowledge. Economic development is directly dependent upon knowledge and information. Poor people and poor countries differ from rich ones, not only because they have less capital but because they have less knowledge. Nations cannot embark upon the path of development unless they agree to transform themselves into knowledge-based and information-based societies. Hence, the correlation between knowledge and power, knowledge and development and knowledge and enlightenment, are no less than axiomatic.

What kind of Knowledge: While acknowledging the crucial importance of knowledge for their socio-economic progress, nations should not compromise on the quality of knowledge. The quality of knowledge should be of universal standing. It is like accepting the quality of medicine. Just as low-quality medicine can hardly bring relief to the patient, similarly low quality knowledge cannot ensure the progress or development of a nation. Low quality knowledge will promote ignorance rather than enlightenment in a society. Economic development of the poor countries will thus largely depend upon the availability and application of the world-class knowledge in science, technology, engineering and in the management skills.

Ethics and Knowledge: Ethical considerations in the application of knowledge, especially the use of science and technology, has been a subject of debate for a long time. Many inventions serve humanity and many others bring destruction to man and the society. It is difficult to stop the progress of research in science and technology which, under economic compulsions, will always lead to products possessing the capability of benefits and also of harm to mankind. It is, therefore, the collective responsibility of scientists and engineers, on one hand, and the corporate world, on the other, to exercise extreme restraints at the policy level, whenever a new product is to be introduced into the market. New research trends involving biotechnology and genetic-engineering, medicinal products, chemicals for crops and foods, arms and ammunitions, satellite- technology, nanotechnology and also fundamental research in Physics, Chemistry, Biology, etc., including their interactive disciplines, need to be carefully scrutinized and controlled by scientists under strict ethical codes. Diffusion

of digital information and applications of unprecedented high power of computers, are becoming subjects of debate all over the world. Widespread availability of ethically undesirable information on the internet and applications of computer-technology, curbing personal freedoms and privacies, is evoking massive protest among societies across the world. "Knowledge with ethics", thus, becomes a vital ingredient for the benign economic progress and peaceful human development anywhere in the world. This important aspect of knowledge and development was also amply highlighted and appreciated by the scientific community during the scientific events which were held worldwide in connection with the celebrations of the "International Year of Physics - 2005" (Hasibullah, COMSATS' Series of Publications (8), 2006, pp. 1-18). The real spirit of the Millennium Development Goals, which aim at the universal economic well-being can hardly be achieved unless the industrialized world and developing countries put collective efforts to strengthen the ethical regimen in their economic pursuits.

III. DEVELOPMENT

The term "development" implies growing, becoming more mature, advanced or organized and by implication, the economic development embodies these very attributes. Hence, development has to be regarded as a process and not as a product.

Human development and economic development have an important correlation. Human development, including the development of mind, depends upon the kind of education and training it has received. It is more likely that a well-educated and trained person or a well-educated and skilful society will achieve faster economic advancement than an illiterate and close-minded society. Knowledge which evolves the mind and the knowledge that provides safety, strength and comfort to the body, both constitute the driving force necessary for satisfactory economic growth. The present discussion will focus upon economic development, per se, and its relationship with knowledge, comprising both social and natural sciences complemented by engineering and technology. Such a treatment of the subject has direct bearing upon the interests of the developing countries where economic development, quite often, is taken only in terms of demand and supply or production and consumption. However, the concepts considered above may not coincide with the standard text-book treatment of the understanding of economic development, but they have been put forth as some of the essential components of development and provide simpler insight into the complex topic of the correlations between knowledge and development. An informative analytical review on development history, interrelation between development and social structural change, development and conflict as well as some recent aspects of development theory, gives the cross cutting characteristics of development which admirably adds substance to the already existing vast scenario of the subject (Barbarti, O., Development and Conflict Theory: www.beyondintractibility.org/essay/development-conflict-theory).

IV. SUSTAINABLE DEVELOPMENT

Although the term "Sustainable Development" is being increasingly used to depict the desired mode of current and future development, its exact meaning has, so far, not been clearly delineat Several dozen definitions of sustainable development are available in the literature, covering a wide array of concepts. In general, the concept of sustainable development still remains ambiguous but some agreement seems to gather around the definition of Brundtland, which states that 'sustainable development is that development which meets the needs of the present, without compromising the ability of future generations to meet their own needs' (Brundtland,G.,Our Common Future, 1987).

The concept of sustainable development takes into account not only the developmental needs of the present population, but also calls for the requirement to meet the needs of the future generations. Clearly this concept is more humane and ethical as compared to the concept of development alone. It points out the responsibility of the present generations to plan and exercise their economic pursuits in such a way that the economic resources are not depleted to such an extent that the future generations are deprived of the benefits of these resources, both in qualitative and quantitative terms.

Sustainable development attempts to narrow the divide between economic growth and environmental protection, in conjunction with other traditional issues related to development. It aims to promote means of supporting economic growth, while supporting biodiversity, reducing poverty and stopping the use of natural capital in the short term at the expense of long-term development. In this respect sustainable development needs more ingestion of knowledge at planning and implementation stages. By implication, embarking upon sustainable development would require more experience, skills and professionalism.

Sustainable development is often misinterpreted as focusing on environmental issues only. But, it is a much broader concept encompassing three policy areas, i.e., economic, environmental and social. Thus, truly speaking, the economic, social and environmental development constitute essential and mutually reinforcing forces for sustainable development. Some interesting notions of weak sustainability, strong sustainability and deep ecology have also surfaced during the course of evolution of the sustainability theory. Further, complications have also been noted due to the conceptual variations revealing tensions between egocentrism and anthropocentrism. Some people tend to reject the term sustainable development as an overall term in favour of sustainability, the former being the process by which one can achieve the latter.

In the real world, development and sustainable development are received and accepted differently. This is due to the prevalence of several 'divides'; economic, social, cultural, digital, knowledge, information and so on. For the rich nations, sustainable development is a preferred requirement for all the development plans to be

undertaken in the developing countries. On the other hand, the poor countries are more interested in that kind of development which would meet their immediate needs pertaining to hunger, poverty, disease and illiteracy. The poor countries attending the World Summit on Sustainable Development held in Johannesburg, South Africa in August-September 2002, amply manifested such sentiments. For them, immediate remedial development, rather than sustainable development was the preferred choice. This was very clear from the official statement made by the President of Tanzania in the same Summit who, inter alia, said, "Agenda 21 was designed to achieve a balance between the needs of people and their environment, balance between the basic requirements of the living and our inescapable, collective obligations to future generations. But the poor, the hungry and the diseased cannot be expected to put the preservation of their environment, above their struggle to survive at present. So they mine soil nutrients, cultivate steep slopes, cut trees for wood fuel and overgraze range lands. Many of them know this is harmful to the environment, but for them, it is not the quality of life that is at stake, it is life itself. For them sustainability is a secondary concern, the primary one is to get the wheel of development turning, and turning faster".

It is, therefore, evident that poor nations whose main concern is "development now" and rich nations who desire sustainable development represent two distinct and different sections of the world community. It is also evident that these two camps of different interests will tackle the changes of development in their own separate ways. Nevertheless, the development in itself is the common interest of everyone and meaningful development will, no doubt, require meaningful and appropriate knowledge. Some further treatment of the subject, i.e., development vs sustainable development and also sustainable developments' specific discussions related to its internationalization, its significance vis-à-vis the Johannesburg Declaration and the world energy requirements of the future, has been attempted elsewhere in the literature, with a view to give an expanded scenario of sustainable development to assist the policy-makers and stakeholders in this field (Khan, H.A. Ed, Road to Sustainable Development, COMSATS' Series of Publications (7), 2006).

V. WORLD ODYSSEY TO SUSTAINABLE DEVELOPMENT

The world has already started a long but arduous journey towards sustainable development. Two famous initiatives are worth mentioning in this regard. One is called the Millennium Development Goals (MDG) and the other is the World Summit on Sustainable Development (WSSD), Johannesburg. The MDGs were derived from the United Nations Millennium Declaration, adopted by 189 nations in 2000. This global agreement lists 8 fundamental goals with 18 specific targets to serve as a blue print and plan of action to address the prominently conspicuous global development problems. The main undertaking is to reduce by half, the proportion of world population living on less than a dollar per day, by the year 2015. The WSSD held in South Africa in 2002 issued its own declaration covering support to MDGs and making renewed commitment to address the issues of poverty, illiteracy, environment, health,

energy, etc., with a well-defined action plan. Five years after the declaration of MDG's, the World Summit under the UN in 2005 reiterated its resolve in the following words,

"We Heads of State and Government … reaffirm that our common fundamental values, including freedom, equality, solidarity, tolerance, respect for nature and shared responsibility, are essential to international-relations…….. We reaffirm our commitment to eradicate poverty and promote sustained economic growth, sustainable development and global prosperity for all ……. We strongly reiterate our determination to ensure the timely and full realization of the …… Millennium Development Goals. We underline the need for urgent action on all sides, including more ambitious national development strategies and efforts backed by increased international support" (UN Department of Economic and Social Affairs – DESA Report, 2006).

The determination of the world community to vigorously pursue sustainable development is amply manifest in the above UN Statement. It is encouraging to note that the objectives of MDGs set out in 2000 were not drained off due to the negative impact of 9/11. The 2002 WSSD in Johannesburg and 2005 World Summit of the UN have boldly and faithfully reaffirmed their resolve in favour of the spirit and substance of both MDGs and WSSD, despite the fact that the actual social, economic and geo-political picture of the world has become more blemished during the six intervening years. This setback has considerably affected the progress towards sustainable development as targeted in the MDGs. If the impeding factors for sustainable development, as seen during the past six years, do not diminish significantly during the next few years, the true achievement of the targets will become extremely unlikely. It is absolutely essential that a congenial world environment is created to realize the goals of MD declaration and WSSD within the agreed time frame. It may not be out of context to say that the MDGs were quite ambitious right from the outset and many analysts were not very optimistic of their timely success even under the existence of a congenial atmosphere.

In any event, it is pertinent to say that under the prevailing circumstances, high quality knowledge has become a compelling necessity for the developing world if it wants to commence its journey on the difficult road leading to sustainable development. Acquisition and sustaining of quality-knowledge by the developing nations will become more necessary if they have to honour the commitments made by them in the first part of the 2005 World Summit Outcome which speaks of the fundamental values including freedom, equality, solidarity, tolerance, respect for all human rights, respect for nature and shared responsibility. Presently this seems no more than a dream which may one day become a reality. After all, many odysseys ventured by man have not ended in total oblivion.

VI. MDGs – PRESENT SCENARIO

It would be useful to consider how much mankind has achieved during the last 6 years

in terms of the targets set by the MDGs, how far the world as a whole has shown collective responsibility in reducing poverty, and what can be reasonably expected in the future. A fair assessment of these issues could easily be made from an analytical overview of the UN Millennium Development Goals Report – 2006. This report has utilized statistics between 1990 and 2004 (not all years inclusive). Out of the eight declared goals, six, (1,2,3,6,7 and 8) are directly linked to the objectives of sustainable development and their results can provide a fairly general picture of what has been achieved so far. While making this assessment, it is assumed that no dramatic changes in the results have taken place in the short period between 2005 and 2006 as compared to the period between 1990 and 2004. These selected MDGs, their respective targets and the results given in the Report have been abridged and shown in Table-1.

A cursory look at the results indicates that the Report tries to present a favourable outcome of the efforts made by the world community for sustainable development between the years 1990 and 2004. However, a detailed analysis of Table 1 shows that the outcome is fairly chequered, with not much of white. Out of 20 results, 2 show upward trend (improvement), 9 downward trend (deterioration) and 9 with mixed trend (improvement in one aspect and deterioration in the other related aspect). The performance as shown by the presence of 9 downward trends and 9 mixed one, is clearly not very encouraging. The two positive results belong to the Goal related to Global Partnership for Development. The 9 mixed trends and 9 negative ones need to be critically examined, strategies readjusted and implementations improved, with enhanced commitments by the governments and other stakeholders. Otherwise, with "business as usual" approach, real and meaningful progress will not be possible for the purpose of world's sustainable development.

Achieving the MDGs in the agreed time-frame will not be an easy job. Firstly, the world community is still divided on the preferences between development and sustainable-development. The developing countries and the least developed countries are seeking short-term solutions due to their hard economic compulsions. Assistance programmes at bilateral and multilateral levels have failed to reduce poverty, hunger, disease, crimes and ignorance in the poor countries during the last century. The development divide between the rich and the poor nations is continuously increasing even in the present century. The design of the MDGs is such that even if all the goals are met in the foreseeable future, the large populations which remain excluded from the MDG's ambit will present the same strong socio-economic problems, perhaps in a more grotesque manner than those identified earlier. This planned social injustice will not be in the best interests of the poor and developing world and for the interests of global sustainable development. The present scenario of the MDG's, therefore, does not seem as encouraging as it was expected to be and hence requires better planning and implementation in the future.

VII. KNOWLEDGE AND SUSTAINABLE DEVELOPMENT

Having realized that much has still to be done to invigorate the MDGs before the

Table - 1: Millennium Development Goals and Targets

Goal	Target	Result
1. Eradicate Extreme Poverty and Hunger	(a) Halve, between 1990 and 2015, the proportion of people whose income is less than 1 $ a day. (b) Halve, between 1990 and 2015, the proportion of people who suffer from hunger.	Asia leads the decline in global poverty. Developing regions still very much below the poverty line. More people go hungry even though worst hit regions show improvement and rates of hunger decline.
2. Achieve Universal Primary Education.	Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary education.	Universal primary education is in sight, though sub-Sahara Africa lags behind. Rural children are less likely to attend school. An educational gender gap persists.
3. Promote Gender Equality and Empower Women	Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education not later than 2015.	Women inch forward in labour markets of all regions, though deep inequalities remain. Women's political power is growing, though men still dominate.
6. Combat HIV/AIDs, Malaria and other Diseases.	(a) Have halted by 2015 and begun to reverse the spread of HIV/AIDs. (b) Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases.	Deaths and new infections continue to increase. New tuberculosis cases are on the rise even excluding those associated with HIV. Malaria persists.
7.Ensure Environmental Sustainability.	(a) Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.	Rapid deforestation continues, but net loss of forest area is slowing down. Energy use has become more efficient in most regions, though carbon dioxide emissions continue to rise globally.

continued...

Table-1 continued...

8. Develop a Global Partnership for Development.	(b)Halve by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation. (c)By 2020, to have achieved a significant improvement in the lives of at least 100 million slum-dwellers. (a) Address the special needs of the least developed countries, landlocked countries and small island developing States. (b)Develop further an open, rule based, predictable, non-discriminatory trading and financial system. (c) Deal comprehensively with developing countries' debt. (d)In cooperation with developing countries, develop and implement strategies for decent and productive work for youth. (e)In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries. (f) In cooperation with the private sector, make available the benefits of new technologies, especially information and communications.	With half of developing country populations still lacking basic sanitation, the world is unlikely to reach its target. World targets for safe drinking water are in sight, but coverage remains spotty in rural areas. Cities in sub-Sahara Africa are growing most rapidly, as are their slums. Led by debt relief, development assistance increase sharply but still falls short of targets. Three quarters of exports from developing countries now enter developed markets duty free. Debt sservice burdens decrease, but for many poor countries even these levels are too high. Job prospects for youth have declined in most regions. More people are receiving treatment for HIV. Access to information and communication technologies grows steadily but digital divide persists.

agreed target date of 2015, a strong, in-depth and authentic approach would be required to achieve meaningful results. The MDGs are based upon the concept of sustainable development, which takes its roots from the well considered concepts of development, thus clearly implying a direct interrelationship between the two. One can arguably say that development can be regarded as a sub-set of sustainable development. Both require authentic and verified concepts of knowledge created out of extensive research and development. The three essential supporting pillars of sustainable development are social, economic and environmental. It seems reasonable that a knowledge-based approach to development and to the sustainable development could give a useful output of the analysis which will, hopefully, be more appropriately applicable to the problems of sustainable development. It must be remembered that sustainable development is a complex phenomenon; it entails prudent use of various contributing forces, like science and technology, human and monetary capital, skills of the working population, while keeping in view the influence factors like politics, religion, economics, security and cultural values. The prudent use needs sound knowledge. This also implies that science and technology alone cannot lead a nation to sustainable development. An excellent analysis, dealing with development, North-South cooperation and the underlying role that knowledge plays with respect to these parameters, has been published and concludes with the notion, "knowledge is becoming a leading factor of production and economic development around the world. We must take steps to create, master and mobilize knowledge for the betterment of our society. For this, we need Human-Capital which requires research and training in frontier areas of science…….".
(Riazuddin, South-North and South-South Collaboration, Proceedings, Khan, H.A, et al,Ed; COMSATS, 2005).

Although knowledge is absolutely vital for sustainable development, one should not confuse it with the literacy rates of a society. Many countries have fairly high literacy rates in Asia and Latin American, yet their developmental levels are not very high. Education does lead to creating knowledge-based societies but in most of the developing countries, the education usually means "certificates" without quality knowledge. Deficit in quality-knowledge and its inadequate penetration into the psyche of a society to create belief and will to take the course of development, would not help the poor countries to achieve economic prosperity. True knowledge-based development is a theoretical and technical field, which is derived from the convergence of a discipline and a movement. The discipline is the Growth Theory in the field of economics and the movement is the knowledge management. These two, combined together, have produced knowledge-based development, a new field of study of the new Millennium, focusing broadly on three important developmental sectors, i.e., social knowledge-infrastructure, human-capital development, and development of the social capital-system. These and some more relevant aspects of knowledge-based development are given in a short paper entitled "A note on Knowledge-based Development", (Carrillo, J., Tech.Note CSC 2003-07) which portrays the above stated sectors as three levels of knowledge-based development. The ideas contained in this paper and their applicability in the flourishing economies seen at national, regional

and inter-regional levels, referred into the note as knowledge cities, knowledge regions and knowledge world, constitute an important and informative reading. The concepts can help to enhance the understanding of the correlation between knowledge and sustainable development.

VIII. SOME LINGERING CHALLENGES

The poor and developing countries have been facing emerging development challenges in the past and, most probably, will continue to face them in this century too. The old economic problems, during the course of their addressal, give birth to new types of challenges and this string of challenges grow thicker and thicker with complicated knots and spirals. The world has already recognized some of these challenges in the year 2000, as mentioned in the United Nations Millennium Declaration on which 189 countries have accorded their agreement. Table 2 gives a glimpse of the enormity and seriousness existing with respect to some selected MDG's which have a direct bearing on the sustainable development to be pursued in the twenty-first century.

The brief information given in this Table and read in conjunction with the given scenario presented in Table 1, is enough indication of the quality and quantity of

Table - 2: Glimpse of MDG Challenges

Goals	Challenge Profile
Goal 1 Poverty and Hunger	In 2002 more than one billion people lived in extreme poverty. An estimated 825 million people in the developing world were affected by chronic hunger in 2003
Goal 4 Child Mortality	Around 10.5 million children died before their fifth birthday in 2004, mostly from preventable causes
Goal 6 HIV/AIDS	The number of people living with HIV has risen from 36.2 million in 2003 to 38.6 million in 2005 with 4.1 million new infections in 2005
Goal 7 Environmental Sustainability	Deforestation, primarily the conversion of forests to agricultural land continues at an alarmingly high rate about 13 million hectares per year. Emissions of carbon dioxide are on the rise, from around 21 billion metric tons in 1990 to about 25 billion metric tons in 2003. There are about 100 million slum- dwellers
Goal 8 Global Partnership for Development	Future debt payments for 29 heavily indebted countries is around 7 per cent of export earning, which is too high. Since 1995, youth unemployment has risen from 73 to 86 million

(Source: The UN Millennium Development Goal Report-2006)

resources to be poured into the melting pot of development in the coming years.

It has been well recognized by a wide spectrum of the concerned persons and organizations of the world that the MDGs and strategies to achieve the targets on time, is an ambitious task. The developing countries do not possess enough resources to effectively pursue the goals all in tandem in a fixed time frame. They will be better off in selecting some out of all, which sound necessary to tackle right at the outset, and which make sense in terms of developing the countries' competences and capacities for useful outcomes. Of course this will depend upon each country's own choices and priorities. Nevertheless, the three most likely areas, which are known to cause major socio-economic set-backs, are population-explosion, energy demands and environmental degradation. All these problems are interconnected and have cross-cutting implications on other MDGs in general and on socio-economic backwardness of the poor countries in particular. The attitude of the world community in dealing with these problems during the past decades gives a fair indication that these issues will linger on in the present century. A brief discussion to understand the nature of these lingering challenges and of some new challenges which may emerge from these lingering challenges would be appropriate to consider suitable adjustments in the policies and strategies of the world, as a whole, in order to deal with them suitably and also to minimize their negative effects on other efforts which are underway to achieve some success in the foreseeable future. It is evident that the power of knowledge will function as the major driving force to create necessary momentum for tackling these challenges.

IX. SOME NEW CHALLENGES

Old and unresolved challenges not only perpetuate the socio-economic problems of the developing countries but also give rise to new type of problems which complicate the present scenario. For example, the population crisis, energy supply-demand complexities and the combined effects of these two on the environmental degradation have direct bearing on the aggravation of poverty, hunger, disease, ignorance, crimes and other social and moral evils. New facets of challenges which emerge out of the old and continuing ills of the developing countries, manifest themselves into such phenomenon as clash of cultures, spread of ethnic hatred, new forms of international crimes, military conflicts, terrorism and other geo-political disorders. The twenty first century is most likely to see these new challenges, in one form or the other, and in varying proportions. The most awaited "world order" in the twentieth century may appear as an ugly and chaotic "world disorder" of the twenty-first century. Human rights, world peace and mankind's dignity could face serious set-backs. Complications arising out of economic and human-rights issues, immigration, human smuggling, autocratic rule over the depressed and poor societies, fast travels and fast information, new viral diseases, tough ailments due to hardened bacteria, possible misuse of biotechnology and genetic-engineering and several other interrelated factors will have serious repercussions over the development of mankind during the present century. These new challenges, growing like a monstrous tree with thorny leaves and pungent

Table – 3: Population, Primary Energy Demand and CO_2 Emission Trends

(A)	Year	1990	2000	2010	2020	2030	1990-2000 Average per year
	Population (Million)	5248	6102	6855	7558	6164	1.29%
(B)	Year		2002	2010	2020	2030	2002-2003
	Primary Energy Demand (Mtoe)		10345	12194	14404	16487	1.7 (2.1% overall)
(C)	Year		2002	2030		2002-2030	
	Energy Related Carbondioxide Emissions (Mt CO_2)		23579	38214		(2.2 overall)	

fruits, will be found to have its tenacious roots in the social wastelands across the globe, infected with population overcrowdedness, energy crisis and environmental degredation. The new challenges of the present century will need strong will and tireless efforts of all the world societies, especially the developing ones, to root out the three major identified menaces related to overpopulation, energy and environment. The trends and projected growth during the crucial first 30 years of this century which will determine the successes and failures of the world's developmental initiatives being pursued at present, have been shown in Table-3.

Table-3 shows continued growth in population, energy demand and corresponding carbondioxide emissions. Growing population requiring growing prosperity needs growing energy. But growing energy means growing environmental deterioration and nullifying a large quantum of economic growth. Slowing greenhouse emissions means putting brakes on the pace of prosperity. A lot has been written on population explosion and its negative effects on prosperity gains. Much has been said on economic and social perils occurring due to climate change (greenhouse gas emissions) and energy production and consumption patterns on socio-economic uplift efforts in the world. Initiatives like Rio, Johannesburg and Water. Energy, Health, Agriculture and Biodiversity improvements (WEHAB) are growingly witnessing the problems associated with energy – GHG complications. Poor countries, already deeply concerned with the lack of clear prospects of quick economic reliefs, are also disenchanted with the uncertainties of several international agreements which hold little promise for poverty alleviation during this century. If no breakthroughs occur in the first 30 to 40 years of this century, it is very likely that poverty will increase and our

planet will not be a pleasant place to live on due to gigantic divides between the overwhelming poor and a minority of the rich. Trends and data shown in Table 3 are just a few small whistle blowers in this regard. The views expressed in the Report "Energy and Sustainable Development" based on World Energy Outlook 2004 (IEA Report, Section 6, pp.32-33), need serious attention of the developed and the developing countries alike. Some of these are summarized below,

i. In case the present trends continue, no matter how we define "sustainable development", current systems of energy supply and use are clearly not sustainable in economic, social or environmental terms. Climate destabilizing carbondioxide emissions will continue to rise, faster than the energy use and faster than in the recent past. Many of the world's poorest people will remain deprived of modern energy-services, upon which their economic and human development depends.
ii. Achieving a truly sustainable energy-system will require significant technological break-throughs in energy production and consumption systems. Advanced nuclear reactor designs and renewable technologies could make global energy system more economically, socially and environmentally sustainable in the long term. Governments must play a central role in the development and deployment of new technologies.
iii. If the Millennium Development Goals are to be achieved, poor countries must accelerate their efforts towards energy development. Developing countries cannot increase their incomes and living standards without a concomitant increase in access to modern energy-services. The poverty reduction target under MDGs is clearly extremely ambitious and highly unlikely to be met.
iv. Adjustments of national policies on energy, trade, regulations, and laws and private public interaction are urgently necessary to move towards the targets of MDGs and others on the priorities of the developing countries. The costs of change are high, but they must be paid eventually.
v. The developed and industrialized countries must play their key role in reducing poverty in the world. The rich countries have obvious long-term economic and energy security interests in helping developing countries along the path to energy-development. As long as poverty, hunger and disease exist, the poorest regions will remain vulnerable to social and political instability and to humanitarian disasters. The cost of extending assistance to poor countries may turn out to be far less than that of dealing with the instability and insecurity that poverty breeds.

X. LOOKING AHEAD

The above discourse clearly shows that the developing societies, which constitute about 80% of the total world-population, have to prepare themselves in this century to break the fetters of poverty and shackles of economic slavery. The twenty-first century may prove to be the decisive century for the future of mankind. Decisions have to be made during the next one or two decades by mankind if it wishes to leave behind an economically sustainable and socially liveable planet for its future generations or it

will leave its future to drift across the oceans of fate. A happy, prosperous and peaceful future is going to be very expensive. Imagine the world population soaring to about 14 billion by 2100, 90 million people added every year; more than 80% living in less developed countries on a course to double their population over the next 30 years; climate degradation taking place, with about 24000 million tons of carbon dioxide being pumped into the atmosphere; 10 to 11 million tons of oil equivalent of annual energy demand and natural disasters increasing progressively due to temperature increases between 1.3 to 5 degree centigrade by 2100 (Options,2006, p.11) and the world community still indulging in mere intellectual debates, complacent agreements, political expediencies and moral indifferences.

The entire world community will have to change its mindset to accept the hard realities arising out of the fast growth of technology and of shrinking time, which is soon going to transform our earth not merely into a global village but into a global villa. In this villa, the inhabitants will be much closer to each other, more intimately experiencing and sharing their pains and gains. A comfortable living for the coming generations can only be ensured if mankind makes necessary preparations for that. One should not expect that enough time is available for bringing a change. Most probably it is this century only which is at mankind's disposal to make the difference. A prudent course of development and of sustainable development ,in the present century has to be undertaken and to be undertaken for sure. This journey is going to be extremely arduous and expensive. Every alteration and repair in the house causes discomfort and difficulties to the residents. But the outcome is more comfortable and pleasant. This discomfort will have to be undertaken by the poor countries sooner than later. They will have to drastically cut down the population growth, adopt strict social discipline and strive hard to acquire knowledge and technology. At the same time the richer nations must reduce energy consumption, adjust industrial output to a reasonable level, adopt measures to reduce environmental pollution and be more forthcoming in sharing wealth and knowledge with the poor societies.

The onus of sustainable development will lie more on the developing and poor nations, than on the richer ones. It is the poorer societies that are to gain more than the advanced societies. The horrors of increased poverty arising out of population-explosion, climatic change and imprudent use of energy will strike hard on developing countries than the developed ones, and consequently, the sufferings will be much more pronounced in the developing nations than the rich ones. The poor nations are handicapped by incompetencies, lack of sufficient capacities, corruption and marginalization. Most of the military-conflicts that cause huge drains on economies, exist in the poor countries. These set-backs have not enabled the developing nations to draw full benefits from the efforts of the world-community through bilateral and multilateral agreements. These international developmental schemes cannot evoke much of the action from the poor societies, which genuinely do not possess enough strength to act. It is a common notion that development does not succeed due to lack of implementation. But at the same time, one should not ignore the fact that most developmental programmes lack operational viability. Take for example, the

philosophy and design of MDGs, recommendations of the Johannesburg World Summit on Sustainable Development and the roadmaps for implementation of the recommendations. It will be instantly clear that neither the vision nor the implementation-strategies are realistic. Broad prescriptions for a wide spectrum of poor countries having their own specific economic, social, political and cultural problems that cannot just fit into the needs of everybody. Each country and each region has its own developmental problems, which need to be addressed on the merit of each case and not by a unique global prescription. This is why most of the UN-sponsored or globally inspired efforts are not succeeding, in general, in the incapacitated developing and the least-developed countries. World strategies, policies and procedures should be redesigned if a meaningful progress is desired to eradicate extreme poverty and conflict. Old stereo-typed designs have not worked in the last century, and are not succeeding in the present century as well and are unlikely to succeed in the future. So, are there any new avenues or perceptions that could help handing the problems of development in a sustainable manner. A World Bank Report, entitled "Knowledge for Development – 1998/99", answers this question in a more logical manner. The arguments presented in this Report are briefly analyzed in the following sections of this chapter.

XI. DEVELOPMENT FROM THE PERSPECTIVE OF KNOWLEDGE

The World Bank Report looks at the development from the perspective of knowledge. The Report proposes that this new approach would be more beneficial for the developing countries while tackling their developmental problems. The Report acknowledges that there are many types of knowledge but two sorts of knowledge and two types of problems need more focus. First there is knowledge about technology which may be called the technical knowledge or simply know-how. Examples are science of nutrition, birth control, software engineering and accountancy. Developing countries have less of this kind of know-how than the industrialized countries and the poor have less of it than the non-poor. These unequal distributions across and within the countries have been termed as knowledge gaps. The second type is called the knowledge about attributes, such as the quality of products, diligence of a worker or creditworthiness of a firm which are all crucial to effective markets. The difficulties posed by incomplete knowledge of attributes is termed as information problems. Mechanisms to alleviate information problems, like product standards, training certificates and credit reports are fewer and weaker in developing countries. Information problems and the resulting market failures especially hurt the poor.

By and large, the argument developed in the World Bank Report on Knowledge for Development 1998/99, is based upon the model of Western development economy. It suggests ways and means of addressing the adverse consequences of knowledge gaps and information problems in the context of sustainable development, through national and international efforts. Strategies and policies are also given to achieve narrowing of knowledge gaps and information failures at national level and the role of international institutions to help the developing countries in this regard. In nutshell,

substantive information is available in the Report to show the importance and benefits of knowledge based development. Governments, academia, private organizations, policy makers and other stakeholders can gain a deeper insight from the contents of the Report.

Sustainable development with the perspective of knowledge can also be helpful for the MDG's and the Action Plan of the WSSD, Johannesburg. The concept, due to its cross-cutting potential, has a good reach to every aspect of developmental plans belonging to MDG and WSSD. The knowledge-based developmental model depicted in the Report which is based on two essential components, i.e., know-how and knowledge about attributes, has a serious limitation for the poor countries. As the Report itself says, "But even if knowledge gaps could be closed entirely, with everyone in developing countries enjoying access to the same know-how as well-educated people in the industrial countries, developing countries would still be at a disadvantage in another respect: knowledge about attributes. Because knowledge about attributes is required for every transaction, it must be generated on the spot and constantly refreshed. This requires a variety of market and non-market mechanisms to collect and disseminate information, many of which are weak or lacking in developing countries". The developing countries have to recognize this limitation while creating knowledge based and information-based societies. Linking information society and sustainability, including discussion on future global challenges has been admirably reviewed in the Conference Report entitled "Towards a Sustainable Information Society" (Conf.Report, June 2000), Relevant extensive information is also available from the Information, Networks and Knowledge Centre's compilation on Knowledge Societies - Information Technology for Sustainable Development, dealing specifically with the role of Information and Communication Technologies in promoting sustainable development (Mansell, R and When. U.,Eds.,1998). The arguments and information provided in these two later publications adds value to the concept of seeing sustainable development from the perspective of knowledge. Nevertheless, lessons learnt by the developing world from previous philosophies and models like the Rostow's take-off model, the Centre – Periphery model and the Marxist model, have to be taken into serious consideration while approaching the knowledge-based development. It may not be in the interest of developing countries to be bogged down by the so-called crisis of development theory and to be led into confusion or ambiguities about their vision and strategies of the country-specific development agendas. The emerging forces of market-led globalization may provide enough impetus to the developing countries to closely examine the benefits of adopting development approaches from the perspective of knowledge.

XII. THREATS AND OPPORTUNITIES

The requirements of knowledge-based development, i.e., closing knowledge gaps and addressing information problems are crucial but are not easy to realize. It is well understood that these gaps and problems will persist, even in the industrialized countries. This constitutes a challenge for the governments everywhere which must

be recognized. The resulting uncertainty demands caution and experimentation whenever possible. The policy makers and policy implementers should recognize the importance of local conditions and the challenge of knowledge for development should combine local knowledge with the wealth of experience from around the world.

The challenge of recognizing the limits of what one knows applies to the understanding of knowledge itself. The study of knowledge for development is a relatively new field where much remains to be done. The main problem is how to measure knowledge. Without a standard measure it is difficult to determine whether knowledge is growing or shrinking. Also it is difficult to determine the society's ability to address information problems and the resulting market failures. Though many policies have been identified to improve the application of knowledge for development, additional work is required.

As the research will advance to make knowledge-based development a better accepted option, so will the global explosion of knowledge expand and will present urgent threats and opportunities. The globalization of trade, finance and information-flow may, in principle, narrow knowledge gaps between the countries, but the pace of acceleration of change in the industrial countries means a widening gap in practice. The prevalent disruption of traditional communities is dissipating informal channels of information exchange and is slowly supplying new institutions in their place. Some information problems, like those concerning the global financial flows, have actually been worsened by recent trends.

The global explosion of knowledge contains both threats and opportunities for the developing countries. If knowledge gaps widen, the world will be split further, not just by disparities in capital and other resources, but by disparity in knowledge. Capital and other resources will flow increasingly to the countries having stronger knowledge bases and hence will increase inequality. The widening of knowledge gaps is also possible within the countries, especially developing ones. If these threatening problems of knowledge gaps are addressed well and the information problems are resolved, there is a good possibility that the developing countries improve incomes and living standards in a much faster manner than previously imagined.

An important challenge for the developing countries will be to decide upon having their own path of development. Each country has to address the problems of knowledge-gap and information failures according to their own circumstances. Poor societies which are hurt most by knowledge gaps and information problems, stand to gain the most from development strategies that take these problems into consideration. The power of knowledge goes much beyond the impacts of some specific strategies and scientific or technological techniques. With the grasping of knowledge which improves their lives, the people are encouraged to seek new knowledge and can become agents of change themselves.

XIII. ROLE OF SCIENCE AND TECHNOLOGY IN KNOWLEDGE-BASED DEVELOPMENT

As development and sustainable development are being discussed from the perspective of knowledge, it seems reasonable to contemplate a little bit on the specific role of science and technology from this particular perspective. The strong role which science and technology plays for economic development needs no emphasis here as much has been written and said about it, and also the world has actually witnessed this fact from the history of the industrialized countries. Knowledge was the essential base for industrial revolution and the ensuing industrial progress in the West, which in turn, generated a lot of knowledge, particularly in science and technology. The wealth created out of this cycle is continuously being diverted towards research and development which is paying handsome dividends to the society. The new geo-political and socio-economic trends of this century are expected to influence the policies of the West to pay more heed to the creation of a society in the West which would be based on the concepts of sustainable development. Thus, the role of knowledge will assume more importance in the industrial societies resulting in greater strides in scientific discoveries and technological innovations. More funding will be made for R&D in the areas of preserving the existing resources, generating new resources, optional use of resources, sharing of resources, creating new demands and new markets, value addition to products, enforcing of intellectual property right laws, etc. Science and technology will continue playing its central role in these ventures. The Economic and knowledge gap between the rich and the poor countries will further increase. Sustainable development will be polarized heavily towards the industrialized countries.

The above scenario demands strengthening of existing base of science and technology in the West and at the same time holds the promise of new discoveries. Earth sciences, biotechnology, genetic engineering, space technologies, oceanography, cosmology, environmental sciences, energy (including fission, fusion and alternate sources), information and communication technologies, nanotechnology and other basic sciences and technologies assisting the sustainable development, safety and security of the society, control on world economic resources and political dominance, will be some of the important areas of basic and applied research in the industrialized nations.

Creation of knowledge for development is a costly affair. Poor countries cannot afford this cost. They have to select those areas and levels of knowledge which give them a modest but meaningful start for economic development. Acquiring, absorbing and applying this kind of knowledge may not be entirely unaffordable by the poor countries. Need based, rather than fashion based science and technologies should be selected by them for R&D and their consequent applications. Government policies of the developing countries should aim at creating enough strength in the society to enable it to acquire and utilize that knowledge of science and technology which meets those countries' immediate needs and which provides a platform to build further

knowledge and expertise on it. This is not an easy task, and this requires strong resolve and serious commitment of the governments and the people together. Unfortunately these two fundamental characteristics are not abundant in many developing countries, therefore science and technology is usually marginalized in these countries and cannot play an effective role in the development of their economies. Models of Japan, Republic of Korea, Malaysia, South Africa, Argentina and Brazil can serve as good examples to learn lessons by the poor and other developing countries for application of appropriate sciences and technologies for developmental purposes. China and India are two other countries where science and technology have played a strong role to pull them out of the pit of poverty. Much can be learned and gained from their approach of acquiring, absorbing, and adapting knowledge for their rapid economic growth. Again, science and technology had a significant role in these two countries in achieving the enviable results in economic progress. Adaptation of knowledge of science and technology to the specific economic needs of a developing country is also a formidable task which in turn requires specialized expertise and specialized domains of knowledge. Table 4 gives a brief description of the areas and specific technologies, exemplifying the nature and level of efforts which the poor and developing countries can start with. The areas selected are those which provide a basic platform for the commencement and progress of economic development and on which further economic structures can be built by many poor and developing countries.

Table 4, by no means, is an exhaustive description of areas and technologies which fits into the needs of every poor developing country, but gives a few examples from which ideas leads could be taken for deciding their own patterns of choice for doable activities.

It is obvious that capacity building, infrastructure strengthening and human resource development are some of the most important requirements for the take-off phase of the development. Of course, appropriate sound strategies, focused policies and continuity of the programmes is the fundamental pre-requisite of such schemes to succeed.

XIV. IMPLEMENTABILITY OF S&T SCHEMES FOR SUSTAINABLE DEVELOPMENT

It may, perhaps, be appropriate to contemplate somewhat on the aspect of implementability of the programmes and schemes in the developing countries. It is usual to note that people are quite satisfied with the identification of socio-economic problems, developmental problems, diagnosis of problems and the plans to resolve these problems, but a large majority complains about the lack of implementation of the programmes and schemes. Thus the biggest hurdle in the acquisition and adaptation of knowledge, its use for socio-economic sustainable development and the lack of progress, or in other words, persistence of poverty and economic backwardness, is attributed to lack of implementation of the policies, strategies, projects, schemes and programmes.

Table - 4: Some Proposed Areas and Technologies for Developing Technologies in Poor Countries

Area	Technologies	Remarks
High Quality Education and Training	Science, technology and engineering education institutions with orientation towards sustainable economic development	Specialized independent and dedicated departments in the universities
Resource mapping	Accurate and reliable resource mapping of the entire country	Fully dedicated organization at national level
Agriculture	Agrotechnologies at rural sites. Back-up small scale mechanical and electrical technologies. Information and communication technologies at remote village level. Org Organic fertilizers, horticulture	Consolidation of the existing scattered potential into a few but better institutional set-ups located in rural areas
Industry	Cottage industry, labour- intensive small and medium scale units like carpet manufacture, sports goods, plastics and metals recycling. Medium level manufacturing of chemicals, cosmetics, detergents, etc., Value addition to minerals, textiles and hand made luxury items (leather goods, gems and stones). Plastic pipes. Low and medium tech. electrical and electronic instruments and appliances.	Expansion of specific industries in industrial zones located near rural clusters and strictly away from the urban populations
Energy	Dams and large water reservoirs for production of electricity and for irrigation, wind-mills, bio- mass, solar panels, ethanol- petrol mixtures, nuclear power plants, energy saving construction of houses and business-malls	Exploitation of indigenous resources to the maximum extent possible
Environment	Effluent treatment technologies for industries based on fossil fuels. Natural products for bacteria or for insect infestation of stagnant water ponds. Biofertilizers. Public transportation (mass-transit). Recyclable-nonplastic packing materials, waste incinerators, etc.	A wide scope of indigenous research and development exists in this area. Engineering universities and other technical institutes can develop special curricula and research programmes.

Realistically speaking, this is indeed a genuine observation and a valid reason for the failure of economic progress and development in the poor and developing countries. Why the sound planning, policies or strategies are not generally implemented, can be attributed to two main reasons. First the governments and societies do not have the will or resolve due to social and political expediencies and second, the societies do not

possess required levels of competencies and capacities, even if they have will and resolve. There are plenty of claims and publicity campaigns in the poor and developing countries about the soundness of policies, plans and projects, but at the end of the day there are no concrete results. One does not have to go through voluminous reports, full of figures and statistics about the success of the developmental programmes, but has just to see the result and ground realities. Mostly, the ground realities are not very pleasant. Poverty, hunger, disease and environmental deterioration are on the rise. Inter- and intranational gulf between the rich and the poor is widening. Contributing factors like protracted political and military conflicts, so-called clash of civilizations, unilateralism and so on, are replacing hope with despair, enthusiasm with dejection and freedom with repression. Crimes, human smuggling, drugs, marketing of children and of human organs, social and psychological distortions and several other vices are increasing in the poor and developing nations. But the governments and pro-government organizations are relentlessly presenting the rosy statistics in the developing countries. The donors and international aid agencies also show much less care in their assessments of the economic progress made in the developing countries under their advice and assistance. The factor of implementability of the aid programmes and the accountability of actual implementation is often put on the back-burner. In short, the implementation of policies and programmes remains only on the paper, television screens or on the web-sites. Lack of implementation of the developmental programmes or their inadequate implementation for sustainable development is very likely to remain as one of the major challenges of this century.

The importance of implementation of the S&T programmes and the related strategies has been amply recognized by the Inter Academy Panel's (IAP) Report – 2004 which has addressed, inter alia, the issues of capacity building in S&T and the inadequacy of S&T knowledge in the poor developing countries which is, by and large, for the lack of economic development. The Report has considered "implementation" as a global issue and has given its opinion and recommendations accordingly. However, many of the observations and recommendations also apply to national scenarios of the developing countries. Some salient points of the Report are given below,

1. It is hoped that the Report's recommendations do not meet the fate of so many other efforts whose thoughtful recommendations garnered political statements and lip service and nothing more. It is essential that things really happen on the ground. An implementation strategy should be developed in order to identify concrete actions for helping international, national and local stakeholders to bring about reforms and introduce necessary innovations.
2. The implementation strategy should include an action plan for the following :

    a. Monitoring the implementation of programmes;
    b. Promoting action networks at regional and global level;
    c. Establishing a clearinghouse for knowledge derived from new information and communication technologies;
    d. Mining the most useful S&T data; and

e. Networking among academies.

The implementation strategy should identify specific milestones to achieve, together with "road-maps" to help countries and S&T communities implement their programmes. Such roadmaps, in a coordinated manner, would be based on the following principles,

a. Design or adopt a sound policy framework;
b. Work with local scientific community to design relevant and achievable projects, the objective mechanism of their selection and evaluation;
c. To seek the support of the relevant government departments and other stakeholders;
d. Identify a 'lead ministry' within the government to organize meetings of involved parties and the World Bank, the regional development banks, foundations and such bilateral donors in the European Union, Canada, Japan, Scandinavia and the USA, among others; and
e. Place through the 'lead ministry' each selected project within a nation's budget and development plan.

The implementation strategy may preferably be put to action through a small, flexible and efficient 'implementation office' and with the assistance of national and regional academies. Even a small office could multiply its effect many times over, if members of the academies are willing to carry out much of the actual implementation work. Further, the participating academies may ensure access to governments, funding agencies and aid groups with which the implementation office would have to interact in order to carry out its functions.

Though the recommendation of the IAP sound attractive, yet they are not easy to implement. The developing countries mostly do not possess professionally sound manpower and other required capacities, particularly the funding, to carry out such jobs. They largely depend upon external donors for the assistance which leads to dependency rather than building the indigenous capability. In this connection, the implementation strategy should include first the training of manpower in the developing countries to equip it with enough skills and competencies to manage implementation in an efficient and cost-effective manner.

XV. SOME CHALLENGES FOR THE CURRENT CENTURY

As the industrialized world is rapidly moving towards knowledge based socio-economic development, the developing nations have to take a closer look at the challenges faced by them during the past century and to foresee the new challenges which they will most probably confront during the present century. Science and technology occupies major space in the domain of knowledge which provides a powerful thrust for the sustainable economic development. While keeping in mind the challenges of the past century, the analysis of some crucial challenges which

developing countries might confront in the twenty first century, becomes an important obligation of every developing country. With this background and in view of the relevant published literature, one may anticipate the following challenges which will present themselves to mankind during the coming several decades,

i. Resolve for Global Development

It is not only the will and resolve of the developing countries alone which is necessary for their economic progress, but also the seriousness of the wish of the developed world to help the poor countries to become prosperous. Sharing of sustainable resources with developing countries without equally substantive returns is hard to expect from the rich nations.

ii. Persistent Increase in the Gap in Knowledge between Rich and the Poor

Creation of knowledge is a costly affair which poor countries cannot afford. They can only acquire some kind of knowledge from the advanced countries and that also on commercial basis. The knowledge reservoirs of industrialized countries are rapidly increasing whereas the poor countries are unable to even maintain whatever they already have. Even if the developing countries try to create indigenous knowledge with heavy expenses, they will be trying to hit moving targets vis-à-vis the advanced nations. Creation of high-quality knowledge is also not a rapid process. It takes decades to create strong universities, scientific and technological institutions and other research organizations and then more decades before knowledge of some respectable quality is produced. With this base of strong knowledge infrastructure, special efforts are needed to make it applicable to the sustainable socio-economic development of a country in accordance with its specific needs and priorities. Knowledge has to be put through an evolutionary process in order to make it compatible with the requirements of outside collaboration. Sustaining a knowledge race by the poor nations, in competition with the industrialized countries, will be a formidable challenge in the twenty-first century.

iii. Building Capacity and Competency

The poor and developing countries have ended up with very modest capacities and competencies in S&T research at the end of the twentieth century. This capacity and competency inadequacy has been recognized as an arch problem for sustainable development in the past and, thus, needs special policy importance by the developing countries to narrow the gap in order to reach a take-off position. Equipment, scientists, engineers, technicians, institutions, libraries, networks, private-public interaction, management personnel and several other building blocks would be needed in a gigantic way to strengthen the capacities and competencies to a reasonable level. In case the developing countries are unable to cope with the funding needed for this purpose in the twenty-first century, the capacity gaps will increase further. The poor and developing countries will then be in a worst economic situation

by the end of this century.

iv. Weakness in Collaboration

The Inter Academy Panel is of the opinion that the inability of most of the developing world to keep pace with the rapid changes occurring in various fields of science and technology indicates that current models of technology transfer and international assistance are not working as well as many would have hoped. The same can be said, in general, for sustainable economic assistance. Creation of new mechanisms and models for purposeful collaboration and assistance at regional and international level will have to be completed soon in order to facilitate the process of global sustainable development. A good deal of lessons will have been learnt around 2020 from the various world initiatives for sustainable development like the MDGs and WSSD which include the components of collaboration and assistance. Nevertheless, overcoming the problems of a meaningful world collaborative arrangement or mechanism for transfer of knowledge and technology from the developed to developing countries will be a sizeable challenge for this century.

v. Dilemma of Economy-Energy

Energy growth is essential for economic growth. But energy growth results in environmental-degradation which in turn hurts economic growth. This dilemma has been widely discussed at length worldwide and so far there is no satisfactory solution. The consequences of economy-energy-environment interaction will prominently appear by the middle of this century as a result of considerably enhanced use of fossil fuels needed for accelerating the pace of world economic activities, complicated by the continuing population explosion. (Around 24000 MT of CO_2 being pumped into the air annually; About 1.3 to 5 degree centigrade temperature increase envisaged by 2100). Such negative effects will be more pronounced in the poor and developing societies than the rich and industrialized countries. The economy-energy dilemma will be a big challenge for the developing countries in the present century.

vi. Retention of Talent and Preservation of Knowledge

It is a well known fact that the developing countries deploy affordable financial resources to create scientists, engineers, technicians, doctors, educationists and managers but a large number of them leave the country due to lack of professional facilities, inadequate salaries and other incentives. The employment opportunities in the industry of the developing countries are also limited as the tendency is to employ cheaper and unqualified work force without any consideration of the quality of products or safety of processes. Thus developing countries, in general, remain short of the 'critical mass' of scientific and technical talent which creates a serious impediment to their economic development. Further, many disciplines of knowledge in the universities and research organizations of the developing countries are vanishing due

to their decreased market. Libraries, archives and other depositories of knowledge are increasingly being marginalized due to lack of funding. The frequent brain-drain from the developing countries and their inability to check depletion of knowledge will be yet another serious challenge which will dominate during the twenty-first century.

The above six challenges of the present century are only a few out of several others which have been selected for consideration in the special context to knowledge based sustainable development at the world scene today. Both the developed and the developing countries are very likely to face these challenges in their pursuit to narrow the prosperity and development gap during the twenty-first century.

XVI. CONCLUSIONS AND RECOMMENDATIONS

The above discussion and analysis of the subject matter leads to the following conclusions and recommendations:

1. Sustainable socio-economic development with the perspective of knowledge is a promising new concept. While developed countries are already moving ahead with this concept, developing countries should make efforts try to adopt this approach in their national and regional strategies aiming at the economic prosperity.
2. Science and technology constitute the major part of knowledge that is necessary for the meaningful socio-economic development of the world. Developing countries should therefor considerably enhance their capacities and competencies in science and technology. Detailed recommendations made by the Inter-Academy Panel-2004 (the Netherlands) should be adopted, as much as possible, to meet the specific needs of any developing country. Only well-chosen technologies for priority areas of direct economic importance should be employed.
3. Creation of knowledge is a costly affair. Developing countries should acquire knowledge from the industrialized countries and adapt it to their local needs. They should also create their own indigenous knowledge for their specific needs, avoiding what is already available and also what is beyond their existing capacities to absorb and sustain. Gradual creation of highly sophisticated and expensive knowledge may be undertaken, in tandem with their economic progress. Equitable balance must be maintained between applied and basic research.
4. High-quality education and training at all levels is essential for knowledge-based societies and knowledge-based economies. Developing countries must create strong universities for high quality knowledge generation. Only talented students should be encouraged to join the universities. Role of Higher Education Authorities should be strengthened to weed out educational organizations producing low grade knowledge and low grade manpower.
5. Lack of vision, defective policies and absence of good governance are some of the main reasons of serious retardation in progress towards prosperity. Development programmes, projects and well-informed decisions often fail due to lack of implementation of the socio-economic programmes. Developing countries should

create a sizeable number of implementation managers to make full use of the resources being spent on the projects in the socio-economic domain.

6. South-South and North-South collaboration mechanisms and models have not worked in the past century as well as one would have expected. The world community should revisit these mechanisms and models in the light of new realities emerging at the present phase of global development. Knowledge based sustainable development will be hard to achieve unless simpler and effective collaboration between the rich and the poor countries is brought into action. Rich and industrialized nations should increase, with more generosity, the transfer of know-how, material products and well tested technologies to the poor and developing countries. Easier economic transactions, removal of information problems and prudent control on intellectual property rights should be given due importance.
7. The history of socio-economic development, evolution of the concepts of sustainability, knowledge-based and information-based societies, the geo-political, social, cultural, religious and racial patterns of the previous century can help provide a clear vision for shaping the new and better structure of knowledge-based and economically sustainable societies in the presently century. Challenges faced in the last century may repeat themselves in this century and some new challenges may also emerge. Particular attention is invited to the six relevant challenges analyzed above in the text. It is recommended that inter Academy Panel-2004 Report may be extensively consulted to search for appropriate solutions which could fit into the specific needs and requirements of the developing countries at national, regional and international levels.

It is clear that the above conclusions and recommendations are not, by any means, a full coverage of the vast and complicated needs of more than 80% of humanity which is suffering from extreme poverty, hunger, disease, ignorance, humiliation and social backwardness. Certainly, there would be more issues and more solutions. An intensive intellectual interaction among all nations of the world could help resolve these issues in a realistic manner. Every developing nation should be able to draw its own set of recommendations suiting their priorities and needs. The reader will be encouraged to advise on further issues and recommendations which will be gratefully considered for the enhanced comprehensiveness of this analysis.

Finally, it may be appropriate to mention that the developing world must look to the future with cautious optimism, as far as their efforts for sustainable socio-economic progress are concerned. The future of the developing countries is hanging in a balance. They can make or break in the present century. Tangible development can commence with seriousness of purpose and by giving due importance to the concept of looking at the sustainable development with the perspective of knowledge. However, the humanity has limited time to act. Given the rapid advancement in knowledge and fast progress of science and technology, there is no time to waste if the majority of humanity is to avoid suffering and marginalization. All the poor and developing countries must act today for a better tomorrow, so that the benefits of knowledge,

science and technology reach everyone and give hope to everybody on this planet to live in dignity, comfort, health, peace and prosperity.

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KNOWLEDGE COMMERCIALIZATION

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1. INTRODUCTION

Knowledge is the engine that drives economy. This has been true over the millenniums for human societies through various shapes of the application of knowledge. The intensity of knowledge viz has increased over the time manifold for role its socio-economic. The earlier man, for instance, used his knowledge of farming as the tool to produce harvest and thus, generate enough wealth for his sustenance.
Today the basic pillars of knowledge-based economy depends on the following:

i. Human Resource: Educated and skilled population of any country is the most vital asset it has.
ii. Efficient Institutional Arrangements: These play the vital role of producing useful human resource. Universities, R&D institutes and their inter-linkages with industry produce local knowledge and result in the creation of new knowledge. Value-addition is achieved and has global impact triggering new products and services.
iii. Information and Communication Technologies (ICTs): Application of ICTs in today's global economy is inevitable, and indispensable with the purpose of innovation, automation and information-dissemination. Our day-to-day life can increasingly be productive by sensible use of ICTs.
iv. Development of Entrepreneurship: This is an aspect of economy that has boosted the developed world to be what it is today. The developing world has yet to realize the importance and potential of entrepreneurship as the driving-force for new inventions, exports and better employment.

The rapid growth of usage of Internet and investment in accompanying softwares and services has led to the emergence of new economic and business models, as well as for sharing of knowledge within different segments of the society. This is fundamentally changing the way in which goods and services are traded today. The emergence of widely accessible electronic market-places, provides new opportunities to sell knowledge-assets and knowledge-intensive products. Exploiting these to their full potential requires new thinking about packaging knowledge and new approaches to marketing.

The Networked Knowledge-Based Economy: In the new economy, the sources of wealth depend increasingly on information and knowledge-resources and less on natural resources. This era is the 'networked knowledge economy', as individuals,

organizations and nations interact with each other globally. It is knowledge-based since in many developed countries, over 70 per cent of workers, including factory-workers, are engaged in knowledge-related work activity i.e., they use brain-power, instead of muscle-power.

Some of the key characteristics of the knowledge-based economy are:

i. Development of 'smart' products and services, e.g., the fertilizer seller that adjusts dosage according to growth of plant, ground and weather-conditions.
ii. Higher value to weight ratios — For example, US overseas trade has grown 20 times in value this century, but the physical weight remains same.
iii. Value in intangibles — For example, the market-value of most companies of USA and UK is five times or more than that recorded in their financial accounts (which only count physical assets like machinery).
iv. Trade in intangibles, ranging from financial products to designs and patents
v. Strong growth in information and knowledge industries, e.g., software, education, management-consultancy, online information-services, and biotechnology.

Knowledge Trends: Shifts from an industrial society to an information-society, a national economy to a global economy, and hierarchies to networking are a growing reality. These trends are evident now. Three phenomenon are especially important now that must be realized:

i. The power of technology and especially the acceptance of the Internet as a key tool of business and commerce
ii. Virtualization: the ability to work and trade over large geographic distances.
Iii. The emergence of knowledge as a key focus of policy and strategy

Of these, technology is the main driving-force. The improvement in price-performance of computers and telecommunications continues to open up new possibilities. Over the last few years, the technology, having the most impact is, the Internet. Internet is not a new phenomenon. Many universities and researchers have used it since 1970s. What changed in 1993 was its use for commercial purpose and the advent of user-friendly graphical user-interface. Its early commercial growth was fuelled by email, which overcame the constraints of time and distance. Thus busy, executives could deal with their messages at a convenient time and place. This was followed by the growth of the World Wide Web, which acts like a global distributed library. It is a storehouse of distributed knowledge, packaged as web-pages, which are hyperlinked to related pages. Internet traffic is doubling every 100 days.

The next knowledge-trend, closely linked to the first, is that of 'virtualization'. As much of today's work is knowledge-based, Internet means that people do not have to go into shops or offices to work and trade. One can buy products and services, from the desktop of computer, over the Internet, without ever leaving his home or office. Mobile phones and notebook-computers have rescued work from the constraints of

geography. People can communicate and share information and knowledge, wherever they are. It is estimated that nearly 10 million people in Europe now work remotely (telework). This brings benefits to employers, in terms of reduced office-costs and organizational flexibility, and to employees, in terms of less travel and being close to their family. Some teleworkers are home-based, while others spend only some time in an office and may work from customer-premises and telecottages (typically shared business-faculties, such as, a converted barn, located in a rural area). Virtualization also means that global organizations can create virtual teams, where different team-members remain in their current location, while working together as if they are in the same place.

Knowledge-management became the focus of business attention around 1995. Recent surveys indicate that over three quarters of the largest organizations, in the USA and UK, have formal knowledge initiatives. At the national level, many countries now have knowledge-initiatives. The UK, for example, entitled its 1998 economic competitiveness white-paper 'Building the Knowledge-based Economy" with key themes of investing in capabilities, catalyzing collaboration and promoting competition.

Taken together these developments mean that organizations and policy-makers must rethink the fundamentals of how they operate. Transaction-costs over the Internet are a tenth or less than the cost of physical transactions. One can access the best resources, both information and people, wherever they are world-wide. Knowledge and information, flows freely. We must learn how to harness it for its full potential.

The Knowledge-Agenda Companies in the West have adopted the knowledge-agenda over the last few years. A typical organizational initiative, creates a focus around knowledge as a dimension of strategy and operations. They create a knowledge-team, drawn from all parts of the organization, but in particular including IT, human-resource management and marketing. Usually they start by making an inventory of their particular industrial knowledge. They invest in technology that helps sharing of information. They build easy-to-search databases of useful information and best practices, and an integrated view of market and customer-information. Above all, they create a working-environment, where it is easy to share knowledge. Effective management and motivation of human resource is a core ingredient for a successful knowledge-based firm or nation.

A careful analysis of developments in previous years can be summarized as 10 macro trends that should influence the way in which any knowledge-agenda is developed. These are:

a. *From a Dimension of Other Disciplines to a Discipline in its Own Right* - knowledge-management is a profession in its own right.
B. *From Strategic Initiatives to Routine Practice* - Knowledge-management becomes an important aspect of every professional job.

c. *From Inward Focus on Knowledge-Processes to External Focus on Knowledge-Businesses* - Companies identify how their knowledge-assets can be recombined to create new knowledge-based businesses. For example, an engineering-company creates an engineering consultancy business.
d. *From Best Practices to Breakthrough Practices* - Rather than improve incrementally, companies should strive for improvements of 10 times or more in key areas, such as, time-to-market, functionality per unit cost.
e. *From Knowledge Codification and Databases to Tradable Knowledge Assets* - Many companies are realizing the opportunities from trading their databases, e.g., fleet-car managers and car reliability information.
f. *From Knowledge Processes to Knowledge Objects* - As computer-applications are object oriented, so will be the application of knowledge. Knowledge may be packaged as objects (that might include an information record, a multimedia clip, and access to a person) that can be manipulated and transmitted in different ways.
g. *From Knowledge Maps to Knowledge Navigators/Agents* - Maps are static representations of objects, and without extensive real-time map-making capability (expected in future), we need other ways to find existing and emerging-knowledge. These will be people with know-where and know-who and intelligent software-agents.
h. *From Knowledge Centres to Knowledge Networks* - Although aggregating knowledge and knowledgeable people at knowledge-centres (such as libraries) gives critical mass, a more effective model is local nodes of expertise, interconnected through human and computer-networks, i.e., the virtual-knowledge centre.
i. *From Knowledge Communities to Knowledge Markets* - Communities, with people having common-interests, have proved an effective vehicle for knowledge exchange. But as knowledge acquires value, and becomes 'productized' as objects these communities may develop payment mechanisms of a market-place.
j. *From Knowledge Management to Knowledge Innovation:* Among these trends there is a clear pattern emerging of exploitation of knowledge-assets, appropriately packaged, in the external marketplace.

2. PACKAGING AND COMMERCIALIZING KNOWLEDGE

Knowledge is packaged and commercialized in many ways. Some examples are given in Table-1. These involve codification from implicit knowledge to explicit knowledge

Table - 1: Knowledge-Packaging

Knowledge Type	**Knowledge Packaging**
Scientific and technical	Journal articles, patents, products
Engineering	Designs, drawings, products
Procedural	Procedure manuals, computer-software
Organizational	Processes, procedure manuals, computer databases
Know-How	Guidelines, best-practice databases
Specific expertise	Expert systems
Factual knowledge	Books, directories

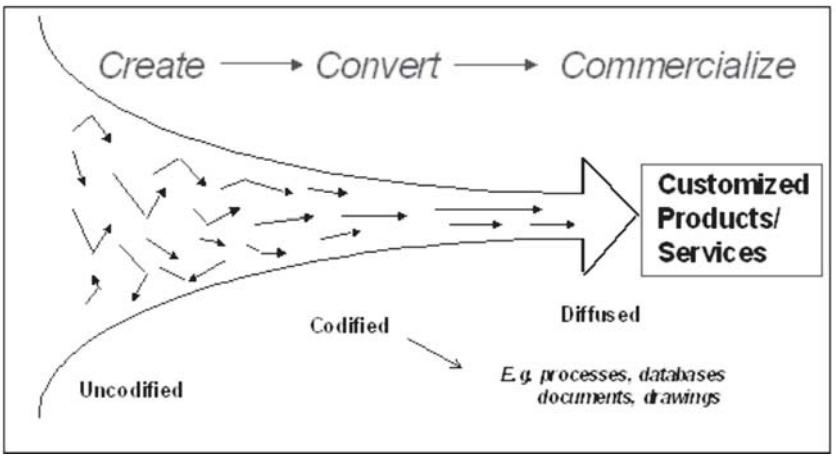


Figure - 1: The Codification of Knowledge into Products and Services

such as, documents, databases and computer-software. Knowledge is shaped into something tangible, such as a process description or a product-design and finally emerges as products for sale (Figure 1).

This is the result of aggregating many different elements of knowledge and applying a design and developmental process. Thus, scientific knowledge about the therapeutic effect of a chemical is encapsulated into a medical drug. The price of the medicine reflects the value of this knowledge, rather than just the value of chemical ingredients. Much knowledge in organizations is neither explicitly codified nor commercialized. Thus, many knowledge-management initiatives identify important tacit knowledge, held by a few experts, that is capable of codification and may benefit many other people. Knowledge can be commercialized in several ways: selling it as part of an advisory service; developing consultancy; developing training courses; and converting it into information products such as, databases.

Much of the knowledge, acquired or created in the development of a new product is not actually used. Yet properly codified knowledge could add additional sources of revenue. Thus, an engineering company, might commercialize some of this unused knowledge by applying codification and selling its market research and design expertise to other companies. New information is also obtained as a by-product of the core business. Car-rental companies, gain useful information on the reliability of different cars, which they may analyze and sell to the car-manufacturers. Even when knowledge is packaged, it requires a special focus to turn it into commercial products or services. For example, academic scientific papers, by themselves, have low commercial-value in the open marketplace (even negative financial-value if you have to pay to have them published). However, their value when converted into consultancy services or new products can be enormous.

Table - 2: Ten Ways to Add Value to Knowledge

Timely	Different kind of knowledge has different rates of value-decay. Up to date, knowledge generally commands higher prices, so time-to-market of perishable knowledge is crucial.
Meta-knowledge	Knowledge about knowledge - directories, indexes. E.g. Yahoo.
Validated and assessed	It is accurate, reliable, credible, validated. Accreditation by a qualified third party will make people pay for it.
Accessibility & usability	The right knowledge is easy to find. There are pointers, tables of contents, indexes that guide users quickly to the relevant items.
Customized	Information relevant to the user is provided. User needs are taken into account when supplying it.
Contextualized	Guidelines for effective use are provided. This includes concrete examples of its application.
Connected	There are many links to related documents and sources.
Know-who	Contact details are provided of knowledgeable people.
Refined	Knowledge is continually refined through use.
Marketed	Marketing helps to create demand, thus, increasing exposure and use that feeds back into higher quality and additional knowledge.

Value of Knowledge in general: The greater the degree of codification of knowledge the more easy it is to reproduce and disseminate. The latest versions of computer operating systems and office software contain over a million lines of computer code, but are packaged onto a CD or downloaded over the Internet. Suppliers could charge a very high-price for software ($10,000 or more), to regain their multi-million dollar development-costs. However, a common strategy is to take advantage of the potential-market and low-price hoping to gain a far higher volume and overall revenue. Some common ways to enhance the value, and hence marketability of information and knowledge are shown in Table-2.

The same knowledge has different-value to different-people at different times. Thus, financial traders pay high subscriptions for real-time stock market and other financial prices, while 15 minutes later the very same information is free on the Internet. An item of technical knowledge is much more valuable to a firm that needs it to overcome a critical problem, than it is to another company without such problems.

Generally, commercialization means making a trade-off between value and volume. Higher-value knowledge is generally specific to the context, and generally involves human interaction. A consultant, for example, charges much more than the book he or she has written, since they are supplying the relevant knowledge from their expertise to the specific situation. But the book is more widely shared.

3. KNOWLEDGE-MARKETS

There are already many examples of trading different types of knowledge. There are industries like publishing and broadcasting. There are also service-based industries like management-consulting (selling the know-how of their people) and recruitment agencies (dealing in Human Resource). Wherever personal knowledge is involved, the marketing has traditionally relied on developing one-in-one (face to face) relationship. The development of knowledge-markets on the Internet, though, is starting to change these traditional methods. For example:

i. *Recruitment-Agencies*: These deal with the trading of human-capital. Some recruitment web-sites (aiming to automate links between companies and individuals) have moved towards a specialist portal, offering hints on writing CVs, giving links to recruitment fairs.
ii. *Management-Consultancies:* These are packaging knowledge, both for internal use (on their Intranets and Knowledge-bases) and externally.
iii. *Problem-Solving Brokers:* Have a network of experts and a thesaurus of knowledge-domains. As clients call in with problems a knowledge-analyst can help find experts, who can solve their problem.

A range of opportunities have opened up, both for suppliers already trading in knowledge-products and services, and also for start-up companies. This new and emergent field of knowledge-commerce (K-commerce) represents a convergence of the Internet (used for marketing and delivery), electronic commerce (providing trading and payment facilities on-line) and the number of innovative ways in which intellectual-capital is being packaged.

3.1 Knowledge Pioneer

One case deserves in depth analysis, viz www.amazon.com

As an online book-store it holds 10 million titles, compared to 20,000 in a typical bookstore is open 24 hours a day, and has a lower cost of sale-transaction. From the perspective of knowledge-markets, amazon.com illustrates:

i. Accessible information from multiple perspectives - you can browse by subject, follow their suggestions, or search in traditional ways.
ii. Personalization - once registered, your details are kept on file and you can do 1-Click shopping.
iii. Links - it suggests other books that buyers of a particular book have also purchased.
iv. Validation, contextualization - other readers can provide their inputs to help you evaluate books on offer.
v. Alerts - it will email you when a new book in your area of interest has been published.

In short, they have developed sophisticated ways of extracting customer knowledge and using this to customize their offerings and suggestions for individual customers. With no effort on their part, they have also created communities of interest, where readers can compare comments and if necessary communicate with each other.

3.2 The Role of Marketing over Internet

Traditional marketing has for many years been focused on strategies developed:

a. Customers: what distinct customer segments are there? What are their needs?
b. Company: what are our organization's strengths and weaknesses? What are our core competences?
c. Competition: who do we have to complete with for the customer's attention?

This analysis leads to selecting market niches where the company has a distinctive competence and can trade profitably by developing appropriate

i. Products: the product and service portfolio
ii. Pricing: setting prices or price bundles that achieve the right balance between volume and revenue
iii. Promotion: making potential customers aware of the value of the product
iv. Place: channels of selling and distribution to reach the target market.

Many of these core concepts carry over into knowledge markets but with some differences. Customers must be given opportunities to learn in low cost ways. Examples might be a free trial period, a sampler e.g. an extract from a document. Pricing, as noted earlier, is much more subjective and depends on perceived value.

When the main trading place (also place of delivery) is cyberspace, a new set of strategies come into play. These are:

i. Packaging - the wide range of formats offer opportunities to package the same knowledge in different ways e.g. as a document, a piece of software, a consultancy service, an online asset.
ii. Positioning - with over 1 billion web pages (and doubling every year), and millions of knowledge products, you must carefully position your product to optimize the match between your strategic aim and your customers' needs.
iii. Portals and pathways - these commonly visited websites (e.g. AltaVista, Yahoo!) are your shop windows to the world. You will need to identify specialist portals that your targeted customers return to regularly.
iv. Page impression(s) - how people perceive your Internet presence is important. Providing useful information, easy to find, and a good visual design are important.
v. Payment mechanisms - one needs to install secure payment mechanisms that accept a variety of payment methods, or use a platform that does this.
vi. Progression - the on-line sales cycle is one where you gradually engage with your

potential customer. First you need to get them interested with useful free information. Then you need to have them interact with your databases to find knowledge that is most relevant to them for a modest fee. Then through some online personal dialogue (e.g. via email) make them aware of more valuable products and services.

vii. Performance - customer expectations for quality, response, value for money are continually increasing. You need to develop metrics for the performance of your Internet presence and the growth in your intellectual capital and how well it is selling.

One of the most effective ways of developing viable strategies is to closely monitor what others selling similar products and services are doing. The great advantage of the Internet is that it is easy to do much of one's learning and competitor-analysis online.

3.3 Success of Knowledge-Market

The Internet makes it possible to trade many different types of knowledge in a cost-effective way on a world-wide basis. Succeeding in knowledge markets is a hazardous business. The pace of change is fast. The speed of development of Internet products and services is measured in days (typically 100 days) not months or years. Some very large organizations have put hundreds of millions of dollars into unsuccessful ventures. Value will flow to where the best knowledge is, to those who best package and commercialize it for different user needs, and those who trade it and provide the enabling mechanisms.

Successful trading and marketing of knowledge is a key plank of prosperity in the knowledge economy. A viable knowledge market must have the following features:

i. An easily locatable marketplace, attractive to potential buyers e.g. via well known portals.
ii. A good source of knowledge assets, through the skills and knowledge of people.
iii. A well organized knowledge schema - so that buyers can quickly visualize the context and understand what is available
iv. Good knowledge wrappers - to quickly and accurately qualify whether what users find is what they really want
v. Mechanisms to sample (try-before-buy) or validate quality e.g. through accreditation.
vi. A fair and transparent pricing mechanism.
vii. Simple and easy payment mechanisms
viii. Effective reward mechanisms, so that there are good incentives to individuals and organizations to develop new knowledge assets
ix. Ways of sharing knowledge between buyers and sellers, and different buyers.
x. Customization based on prior usage for the customer's needs.

There are many opportunities for entrepreneurs in addressing these needs. They must

also address any legal or regulatory hurdles - not so easy in the field of electronic commerce where laws often conflict and national laws are not in harmony with each other.

3.4 The Global Opportunity

This fast developing knowledge economy poses many opportunities for wealth creation (in the US knowledge intensive industries are believed to be the main factor behind recent economic growth). Analysis of successful regions such as Silicon Valley in the USA offers some useful pointers. They have strong innovation networks with local education and research, access to financial capital, access to business and entrepreneurial know-how (including commercialization know-how) and an appropriate technological infrastructure e.g. high speed access to the Internet.

What is important is to distinguish between knowledge-inputs, processes and outcomes (Figure 2). Certainly a strong research-base and highly educated workforce will be a key ingredient in creating knowledge-based wealth, but probably more important is having the right processes and infrastructures to convert knowledge into goods and services. This also requires bring together different players in knowledge-markets: content providers, software-suppliers, telecommunications-operators and main users.

It is individuals, business and community networks that are the real focus of action. Governments can only create suitable environments. It is the entrepreneurs and innovators who build the knowledge enterprise of the future and participate in global knowledge markets. They can participate in new markets, and learn the tools and techniques to succeed. Demanding consumers stretch suppliers to new levels of performance.

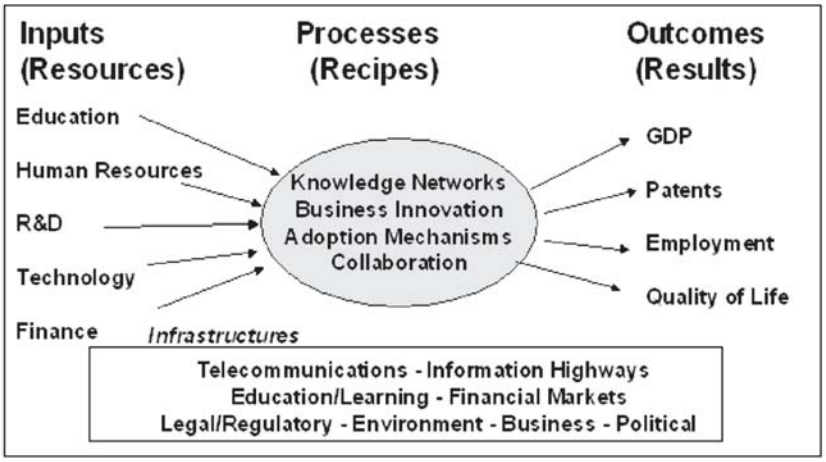


Figure - 2: Knowledge Economy Model

The role of government is:

a. Leadership - creating the vision, developing partnerships
b. Creating a fair regulatory framework, in harmony with international best practices
c. Being an 'intelligent' user - an example of the online economy in action
d. Stimulating entrepreneurship and new initiatives
e. Building essential infrastructures - ranging from education, telecommunication, financial investment, etc.

The key challenge is to tap into knowledge, add one's own unique talents, and create knowledge-based products and services that will help create a sustainable and prosperous world.

Now we shall look in detail at the case studies on transformation of two countries into knowledge-based economies. These are case studies of Ireland and Finland. Being knowledge-based economies they have progressed a lot in recent decades and their economies have skyrocketed. They can be a role-model for any developing country to follow their model, in accordance with their own environment.

4. CASE STUDY OF IRELAND'S KNOWLEDGE-BASED ECONOMY

Ireland is an advanced and developed country of Europe, while being 4th in world Human Development Index (HDI) ranking. It has a powerful and growing knowledge economy. The Irish experience is a role model for other countries to follow, who aspire to develop themselves into knowledge-based economies. Ireland is working hard for further improvement in its R&D infrastructure to enhance its knowledge-economy and has set ambitious targets for itself for the year 2010.

4.1 Introduction

Europe is lagging behind the leading economies of the world viz performance of R&D in both the public and the enterprise-sectors. Gross expenditure on R&D is currently at 1.9% of GDP in the EU, compared with 2.7% in the US and 3.1% in Japan. Within the EU, Ireland's current R&D performance is about two-thirds of the EU average, at 1.4% of GNP. See Figure-3.

GNP is a more appropriate measure of national output for Ireland than GDP due to the transfers within multinational organizations located in Ireland. The Irish economy has been transformed over the last decade, experiencing unprecedented rates of growth in productivity, jobs and living standards. Advances in S&T are having a significant impact on all aspects of Irish society and economy and have, compared with growth in domestic services, underpinned much of the increased prosperity of recent years.

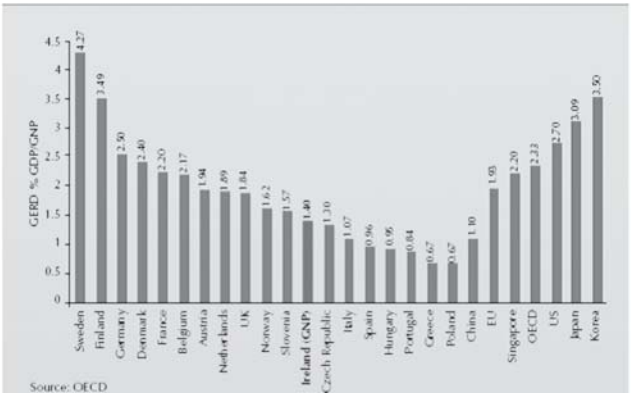


Figure - 3: Gross Expenditure on R&D as % GDP/GNP, 2001

The empirical evidence is that Irish enterprises that perform R&D are more likely to survive longer and provide higher quality and better paid employment. Enterprises are increasingly accessing knowledge and new ideas from around the world to grow and compete on world markets and to provide sustainable high quality employment.

Two-thirds of the current gross expenditure on R&D in Ireland is being undertaken by the enterprise sector, with two-thirds of business R&D being performed by overseas enterprises in Ireland. The higher education and public research base performs the dual role of broad high level research across all disciplines and targeted research in areas of key national interest. In addition the higher education sector supplies high quality graduates for both the enterprise and public sectors.

The Irish Government recognizes the importance of achieving a step change in R&D performance. The level of Government investment in research and technological development and innovation is increasing from € 0.5 billion in the period 1994-1999 to € 2.5 billion over the period of the National Development Plan, 2000-2006. The Government has also introduced an R&D tax-credit to encourage enterprises to invest in R&D, following detailed consideration by the Ministers for Finance and Enterprise, Trade and Employment. The higher education and public sectors have made major advances in developing research excellence, utilizing funds from the NDP along with other national and international sources.

Investment in R&D is also at the heart of the European agenda to improve economic growth and competitiveness. At Barcelona in 2002 Heads of State agreed to a target for Europe for gross expenditure on R&D to reach 3% of GDP by 2010, from 1.9% currently. They also agreed that two-thirds of the increase in R&D should come from the enterprise sector.

4.2 Ireland's R&D Performance: Ireland has taken significant steps towards increasing the quantity and quality of R&D over the last decade. R&D in both the public and private-sectors has increased three-fold over the period, and reached over € 1.32 billion in 2001. Business R&D grew at an annual average rate of 15 per cent over the period 1993-1999, although from a relatively low base.

4.3 R&D in Indigenous Enterprises: Almost 1,000 indigenous enterprises in Ireland had some expenditure on in-house research and development in 2001, equating to approximately 1 in 3 enterprises in the relevant indigenous base. Almost half of these enterprises spent less than € 100,000 on in-house R&D in 2001. Of the remaining enterprises, there were just over 150 with expenditure in excess of € 500,000. The top 50 enterprises accounted for 43% of the total expenditure on in-house R&D by the indigenous base (See Figure-4).

More than half of indigenous R&D expenditure is accounted for by the Information and Communications Technology (ICT) sector. The food and drink sector accounts for the next largest proportion of expenditure together with services.

4.4 R&D in Foreign Business Enterprises: Foreign-owned multinationals spent almost € 600 million on in-house R&D in 2001 and this maintains a steady pattern since the early 1990s with foreign-owned enterprises accounting for two-thirds of business expenditure on R&D in Ireland.

In total, there are almost 300 multinational companies active in R&D in Ireland. Almost half of these R&D performers spent in excess of € 0.5 million on in-house R&D in 2001 and it is estimated that there are 19 multinational companies with R&D expenditure in excess of € 5 million per annum (See Figure-5).

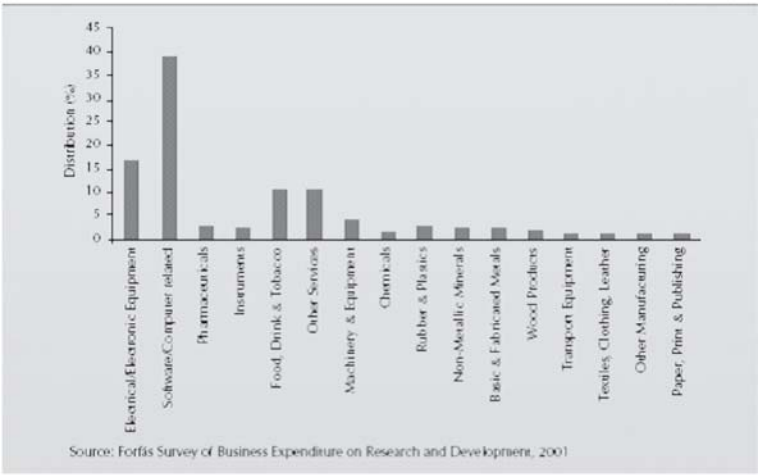


Figure - 4: Distribution of Indigenous Firms R&D by Sector, 2001

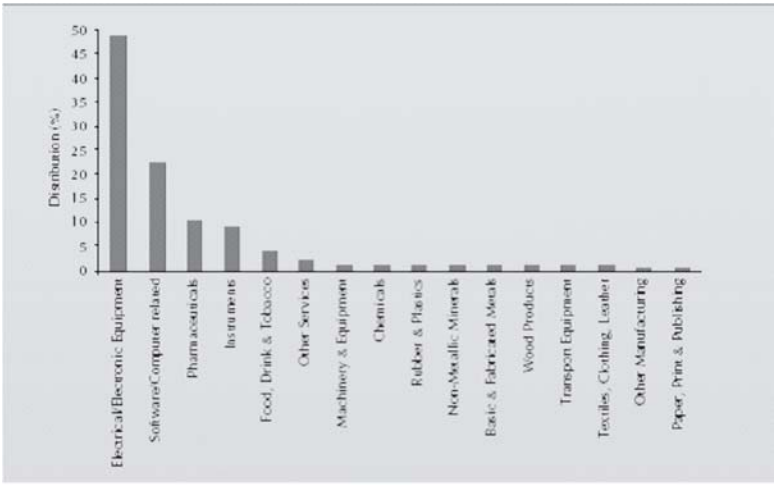


Figure - 5: Distribution of Foreign Firm R&D by Sector, 2001

The ICT sector accounts for the bulk of multinational R&D in Ireland. The pharmaceutical sector and the instruments sector together account for another 20% of the R&D expenditure of multinational companies in Ireland and for 11% of research personnel in enterprise.

4.5 Higher Education and Public-Sector Research: Throughout the 1980s and 1990s, there was little scope to carry out high quality research in universities in Ireland due to a lack of research-infrastructure and a lack of funding to support researchers. The EU framework-programmes (FP) were the only substantial sources of funding available to Irish researchers in that period.

Since 1998, a number of significant actions have been taken, enabling the Higher Education sector to build infrastructure and fund high-quality research-programmes. Generous donations by Atlantic Philanthropies (US based philanthropic organization), complemented by exchequer funding, provided the basis for the Programme for Research in Third Level Institutions (PRTLI). This bottom-up programme, operated by the Higher Education Authority, (HEA), enabled universities and institutes of technology to develop and realize long term strategic plans for research infrastructures and research programmes. In 1999, the Technology Foresight exercise recommended significant state investment in a number of key disciplines. Following on from this, the National Development Plan (NDP) 2000-2006 committed € 2.48 billion to R&D and specifically set aside € 648 million for a new foundation for research excellence, Science Foundation Ireland (SFI). The NDP also committed support for Teagasc, the Marine Institute and others. In addition, since 1998, two new research councils have been established, the Irish Research Council for Science, Engineering and Technology (IRCSET) and the Irish Research Council for Humanities and Social Sciences (IRCHSS). The principal activity of these Research Councils is the

support of postgraduate and postdoctoral research across all disciplines in order to build a strong base of highly qualified researchers. In addition to the NDP, the Health Research Board (HRB) now provides significant funding for "bench to bedside" research.

The bulk of Government funding for R&D (88%) goes to the public research organizations and third level sector. While Government investment dominates performance in the higher education and public research sectors, the impact of Government investment on business expenditure on R&D is only 4.5%.

Research investments under PRTLI and SFI have led to a significant strengthening of the research base. Under PRTLI, 24 major research centers (funding over € 5m each) have been established. About 50% of PRTLI investment is in the biosciences/medical fields, 10% in environmental/marine, 8% in ICT and also in engineering/materials and 7% in social sciences/humanities. Total R&D allocations within the national budget for 2002 amounted to € 390 million.

The principal R&D performers in the public sector in 2002 were Teagasc (Irish Agriculture and Food Development Authority) and the Department of Agriculture and Food. Recent research in the marine sector by the Department of Communications, Marine and Natural Resources and the Marine Institute are world class.
Enterprise-Academia Research Collaboration

A key feature of knowledge-based economies is their ability to convert knowledge from the research base into products for economic and social benefit. This is dependent on collaborative research between industry and academia.

The development of the SFI Centres for Science, Engineering and Technology (CSETs) is an important initiative to address issues between industry and academia. Joint research of Irish foreign companies is linked with third level education inside Ireland.

4.6 Human Resources and R&D: A strong research base in any sector requires that highly qualified people are available to carry out that research. Overall, Ireland in 2001 had the equivalent of 5.1 researchers per 1,000 of total employment in the economy in 2001.

The Irish education system is producing more science and engineering graduates as a proportion of total third level graduates than most other countries. In 2000, 35% of graduates were in science and engineering in Ireland, compared with 30% in Finland and Austria, 18% in Denmark and 15% in the Netherlands; the EU average was 26%. Ireland also leads the table in terms of number of science and engineering graduates as a proportion of the population aged 20-34 in 2000 (16.3 per thousand compared to an EU-15 average of 6.8 per thousand). Ireland is producing high levels of technical graduates as well.

4.7 The Vision 2010: "Ireland by 2010 will be internationally renowned for the excellence of its research and be at the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture".

The Government's stated objective is to develop Ireland as a powerful knowledge-based economy. Ireland is competing with Finland, Denmark and the Netherlands. A target of 2.5% of GNP by 2010 for total R&D (GERD) has been set. That includes:

- business investment in R&D should increase from € 917 million in 2001 (0.9% GNP) to € 2.5 billion in 2010 or 1.7% GNP;
- the number of indigenous companies with minimum scale R&D activity (in excess of € 100,000) should double, from 525 in 2001 to 1,050 in 2010;
- the number of indigenous enterprises performing significant R&D (in excess of € 2 million) should increase from 26 to 100 by 2010;
- the number of foreign affiliates companies with minimum scale R&D activity (in excess of € 100,000) should double, from 239 in 2001 to at least 520 in 2010;
- the number of foreign affiliates performing significant levels of R&D (in excess of € 2 million) should increase from 47 in 2001 to 150 by 2010;
- R&D performance in the higher education and public sectors should increase from € 422 million in 2001 (0.4% GNP) to € 1.1 billion in 2010 or 0.8% GNP;
- The combined increases in performance in business, higher education and public sector R&D should result in gross expenditure on R&D increasing to 2.5% of GNP by 2010;
- Consequently, the number of researchers should reach 9.3 per 1,000 of total employment by 2010, from approximately 5.1 per 1,000 in 2001.

Increased R&D performance is essential to develop Ireland as a location for high-tech and knowledge based industries, to embed the existing multinationals here and to create new indigenous industries. As technology levels in Ireland improve, innovation will assume a greater role.

4.8 Gross-Expenditure on R&D to Reach 2.5% of GNP by 2010: Concerted action is required by all in the innovation system to promote R&D investment and culture in the public and private sectors. As Irish economy is growing at 2 to 3 times the rate in other EU countries, Ireland has to increase annual expenditure on R&D to maintain its position.

4.9 Increasing Business R&D Performance: To increase the productivity and competitiveness of existing enterprise and to increase the development of new marketable products and processes through R&D and technology transfer the following targets for the enterprise sector are recommended. The number of enterprises involved in R&D should more than double to 2010 and business R&D should rise from € 917 million in 2001 to at least € 2.5 billion in real terms over the period.

All enterprise sectors need to contribute to increasing total business sector R&D. At present up to two thirds of BERD is accounted for by the electrical/electronic equipment and the computer/hardware sectors. There is scope for a much improved performance from the pharmaceutical, healthcare/medical technologies and food sectors.

4.10 Increasing Higher Education and Public Sector R&D: A vibrant research activity in higher education and public research system can lead to technology transfer to enterprise and new start-ups based on the commercialization of research.

Analysis for this Action Plan projects that it is possible to achieve more than a doubling of performance in the higher education and public research sector to reach at least € 1.1 billion by 2010. This requires a serious commitment by Irish government to continue the current investment in R&D. The researchers (higher education and public sector) may continue to access international sources of funding.

4.11 Increasing Researchers in Employment by 2010: Ireland currently has 10,200 researchers in enterprise, the higher education and public research sectors, 10% of which are at doctorate level, 50% degree and postgraduate level and 40% technical support. It is projected that Ireland requires an additional 8,000 researchers over the period to 2010.

The type of researcher required by industry and academia is different. Currently approximately 90% of industry researchers are non PhD while all academic researchers are either post-doctoral or studying for a PhD. In order to achieve the targets for business expenditure on R&D, Ireland needs to have high quality researchers available to stimulate this level of demand. As Irish industry becomes more R&D intensive the relative demand for PhD scientists will increase.

4.12 The Action Plan for Achieving the Vision: The Irish Government needs to be a strong advocate in the drive to boost research and technology development in enterprises. To build the science base and the enterprise research base, the following actions are recommended:

a) National Pro-Innovation Culture

i. Develop a national pro-innovation culture supportive of invention, risk-taking and entrepreneurship.

b) Research & Development in the Enterprise Sector

ii. Re-orient the enterprise support budget to R&D and develop a new and less bureaucratic approach to R&D support that encourages a systematic and continuous approach to R&D within enterprises.

iii. Strongly support the development of strategic research competencies (technology platforms) based on enterprise needs.

iv. Develop the seed capital-markets for early stage ventures.

c) *Research & Development in the Public Research System*

v. Develop a national plan to increase the performance, efficiency and productivity of research in the higher education and the public sectors.

vi. Sustain Ireland's commitment to building its international reputation for research excellence.

d) *A Highly Attractive Environment for Researchers*

vii. Make Ireland a highly attractive environment for high quality researchers and research careers.

e) *Turning Knowledge into Products and Services*

viii. Develop the intellectual property management and commercialization expertise and resources necessary to ensure effective and rapid exploitation of research generated in higher education and public research sectors.

4.13 S&T Policies: Science, technology and innovation policies need to be consistent, coherent and predictable. For Ireland to develop as a more innovative and competitive country, a national culture that is supportive of both invention and risk taking at all levels in economic and social life is required. Ireland still lags behind other European countries in terms of an entrepreneurial culture.

In seeking to develop a knowledge-based economy, there is a strong rationale for increased State support for enterprise R&D. Measures such as R&D tax credits promote a continuous and systematic approach to R&D in enterprises. The decision to introduce the 20% tax credit for incremental R&D in the Finance Act, 2004 is very valuable to industry. Ireland should move to a full volume based R&D tax credit.

To facilitate greater interaction between academia and enterprise, Conference of Heads of Irish Universities (CHIU) should promote searching for research partners and showcasing commercial opportunities.

Small open economies cannot be competitive or develop the required critical mass in all areas of science and technology. There is a need for focus and for expenditure to be prioritized within an overall coherent framework that promotes national developments objectives. Significant progress has been made since the establishment of the HEA's PRTLI and SFI in developing the research base, promoting research excellence in Ireland and undertaking high-risk fundamental research. In addition, Irish enterprise needs a good balance of Strategic-oriented Basic Research and near to market research.

Enterprise Ireland and IDA Ireland need to develop a networking and cluster-led approach to bring together enterprises, regardless of nationality, to determine areas of importance for common research that will underpin the development of new products, processes and services for world markets into the future.

The development of cluster-based research agendas would serve to target funding to strategic areas where Ireland can develop internationally recognized Applied Research competencies. There is a need for the private and public sectors to fund and develop the research competencies in the higher education and public research sector to meet the needs of the enterprise base and to enhance technology spillovers and networking between enterprises. The adoption of a cluster led approach would also enable identification of related areas that Ireland needs to influence, such as in regulations and standards, including EU Directives.

Research funding and development agencies need to further develop their understanding of the technology roadmaps of key industries and enterprises. They need to further develop their technology assessment and intelligence capabilities, monitoring developments in Ireland and internationally and feeding back intelligence to the policy and research system.

The Venture Capital market in Ireland has developed considerably over the last decade. However it is primarily focused on opportunities in the Information and Communications Technologies sector (ICT). Areas such as biotechnology are now attracting a growing proportion of national research funding; but relatively fewer opportunities in these areas have been funded to date by Venture Capitalists. The continuation of the Seed and Business Expansion Schemes is also welcomed and essential to the growth of technology based industries. European Investment Bank investments in Irish venture capital funds should continue to be encouraged.

Increasing Ireland's higher education and public sector R&D performance to € 1.1 billion per annum by 2010 will require a major investment by the state, sustaining the current commitment to R&D. This is the level of performance required to produce the trained researchers, technology and ideas for a knowledge based economy.

An integrated plan should be developed to target funding for research and commercialization including EU Framework Programmes, research foundations, venture capital and other sources. At the end of 2003 the European Commission with the European Investment Bank agreed a joint initiative to provide € 60 billion in loan finance to support investment in R&D infrastructure projects in the public and private sectors in Europe over the period. Accessing this type of funding would require changes in legislation to enable the research institutions to expand research infrastructure.

Ireland will require, at least, an additional 8,000 researchers over the period to 2010. A minimum of 3,600 additional high quality researchers will be needed to be made available through a combination of further increases in domestic supply and attraction of researchers from abroad. Sustained investment in the Higher Education system is an essential platform for the knowledge economy.

Similarly there are opportunities to upgrade the skills and qualifications of the existing

workforce and to encourage greater participation by women in science, engineering and technology research careers. There have been some improvements in the procedures for issuing Work Permits to non-EU researchers. Irish Government must improve the entry conditions for third country researchers and their family members. By moving quickly Ireland can take the lead over its European competitors. Mobility of researchers between public and private sectors should also be encouraged to improve ideas' flow.

The production of primary research information is not the end but the beginning of a process that continues until the usefulness of that information is realized. The commercialization of research and knowledge for Ireland's economic benefits through effective intellectual property management and technology transfer should be a priority for all higher education and public research institutes. Technology transfer offices' personnel need continuing professional development and training. Research funding bodies must provide appropriate support as the Irish Commercialization Infrastructure develops. Incentivising researchers to recognize the commercial potential of their work is essential.

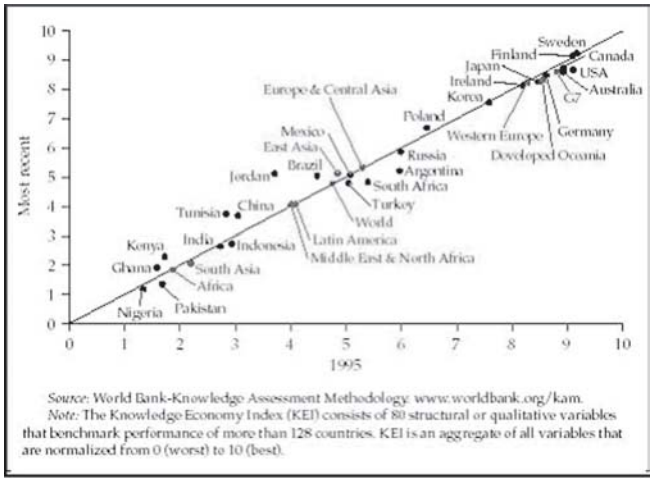
4.14 Conclusion: Ireland has the potential to achieve a step change in R&D performance over the period to 2010. Ireland has a strong private research base and the potential to increase its R&D capability and knowledge generation. It also has a growing public research base. Ireland's future economic leadership depends on its success in stimulating more business R&D and effective linkages between enterprise and academia.

As a Knowledge-based economy, putting R&D at the heart of its economy, increasing productivity and competitiveness through R&D and creating a powerful knowledge commercialization infrastructure will sustain this change and enable the quality of life for Irish people to rise.

5. A CASE STUDY OF FINLAND AS KNOWLEDGE-BASED ECONOMY

5.1 Introduction To Finland As A Knowledge-Based Economy: This case study is on Finland, a country that has successfully transformed itself into a knowledge-based economy in a short time. The Finnish experience of the 1990s represents one of the few examples of how knowledge can become the driving-force of economic growth and transformation. Four times to-date, since the beginning of the twenty-first century, the country has ranked as number one in the World Economic Forum's (WEF) competitiveness-index, and also achieved the highest Knowledge- Economy Index in the World Bank comparisons (Figure-6).

The various elements pertinent to a knowledge-based economy are economic incentives, education, innovation, and IT infrastructure, which all seem to be well balanced in Finland. This achievement is quite remarkable especially when considering Finland's economic situation in the early 1990s. The country went



Source: World Bank-Knowledge Assessment Methodology. www.worldbank.org/kam.
Note: The Knowledge Economy Index (KEI) consists of 80 structural or qualitative variables that benchmark performance of more than 128 countries. KEI is an aggregate of all variables that are normalized from 0 (worst) to 10 (best).

Figure - 6: Global View: Knowledge-Economy Index by Countries and Regions, 1995 and the most recent year

through a severe economic recession, characterized by a major banking crisis, unemployment-rates rising from 2-3 percent to over 15 percent, and the accumulation of government's debt from modest levels to over 60 percent of GDP, and approaching international lending limits. These difficulties were caused and exacerbated by uncontrolled deregulation of financial markets and a rapid increase in foreign-borrowing, which led to an overheated domestic economy. High inflation pushed up interest-rates and overburdened the public sector due to smaller tax revenues and larger unemployment and welfare costs. Furthermore, the collapse of the Soviet Union, wiped out 15 percent of Finnish foreign-trade with attractive barter arrangements. Finland's difficulties were amplified by its not being well-prepared for economic integration and globalization, its membership in the European Union (EU) and Monetary Union, and its lack of export diversity.

This case study explains Finland's position as of now, which is much stronger as a result of consolidation and the emergence of a few multinational companies with advanced technologies and market-approaches. Thus, the diversification of exports has been mandatory to improve the performance of the Finnish economy, and it has been due largely to the persistent emphasis given to higher education, linkages and spillovers among various industries, and the emergence of new knowledge-based industries. The Finnish innovation-system also has been successful in converting its R&D investments and educational capacity into industrial and export-strengths in the high-technology sectors.

Today, Finland's exports of telecommunications are as high as those of its forest-related industries, and the Finnish Nokia Corporation has grown into a world leader in mobile communications. Hundreds of other smaller high-technology companies also have been established, and many have become world-leaders in their niche-markets.

5.2 How did Finland become a Knowledge-Based Economy?: As late as the late 1970s, Finland ranked at the lower end of the OECD countries in R&D intensity. Today, Finland's investment in R&D accounts for approximately 3.5 percent of GDP, which is the second highest in OECD and the third highest in the world, just after Sweden and Israel. Increasing investments in R&D during times of high unemployment required great political wisdom and courage, when an easier path would have been to generate immediate employment rather than build up longer-term strengths. Increasing

R&D was helped partially by national industrial and innovation strategies communicated by the government. These national strategies were important for consensus building, for example, by organizing economic policy programs attended by practically all members of the Finnish Parliament and other decision makers from the public and private sectors, media, and labor market organizations.

A peculiarity of the Finnish case is the atypical pattern of industrial renewal from essentially natural resource-based industries toward machinery, engineering, electronics, and ICT. There are few, if any, other examples of natural resource-abundant countries that have managed to transform their industrial structures toward higher knowledge intensity and value added so rapidly and successfully as Finland. The origins of the Finnish knowledge economy can be traced back to user-producer linkages between the forest-based industries as early users of high technology, and the emerging engineering, electronics and ICT industries in the 1960s and 1970s (Figure-7).

In addition to Nokia, industrial and innovation policies contributed to the development of the Finnish knowledge based economy, both indirectly and directly.

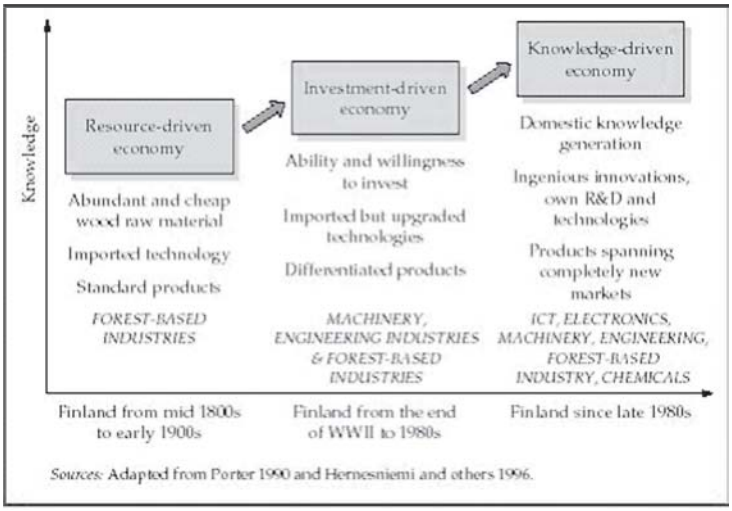


Figure - 7: Finland's Stages of Industrial and Economic Development

Especially noteworthy is the shift in the focus and content of industrial policies in the 1990s away from macroeconomic policies and industrial subsidies toward microeconomic "conditions-providing" policies. The latter put R&D and innovation center stage. Public subsidies are now increasingly R&D based, and market failure remains the main justification stated for these policies. In addition, most public research funding is competitive—that is, not only companies but also research institutes and universities are put in competition for the project financing provided by various government agencies.

Presently, private funds account for some 70 percent of the total. The increase in private R&D is attributable, above all, to Nokia. Although there are also other firms, Nokia was the industrial engine for developments in the ICT industries in Finland. Nokia thereby to a significant extent influenced the rapid industrial restructuring in the 1990s toward electronics and electrical engineering

5.3 Industrial and Innovation Policies: Specification of the Finnish System: A specificity of the Finnish "model" has been the early application of a systems-view of industrial policy. This systems-view could be described as an acknowledgement of the importance of interdependencies among research-organizations, universities, firms, and industries, due to the increasing importance of knowledge as a competitive-asset, especially in the case of small open-economies with a well-developed welfare-system.

However, it is important to stress that a systems-view of industrial policy does not imply that Finland has followed a "master plan", in which the government played a strong leading role. Rather, the systems-view was concretized through an emphasis on responsive longer-term policies, to improve the general framework-conditions for firms and industries, especially in terms of knowledge-development and diffusion, innovation, and clustering of industrial activities. The systems-view was formulated through various public-private partnerships, involving economic research-organizations, industry-federations, and firms; and was anchored in broader economic policy-circles.

The collaboration between funding and innovation-promoting agencies is based on the systemic model of innovation. The various stages of the innovation process—from basic research to commercialization—are funded simultaneously to a greater extent than before (Figure-8). This new funding logic, demands closer collaboration and coordination among the various public and private-sector funding-organizations. The collaboration intensified in the 1990s during the ICT boom and has proved to be important in many other fields of science and technology as well.

Good governance and political transparency play an invaluable role in the Finnish society, particularly in its knowledge economy. Institutions, both administrative and political, also do matter. One example of institutional innovation is the Committee for the Future, a standing committee of the Parliament of Finland, which has signified the need for longer-term orientation and consensus building in politics and the

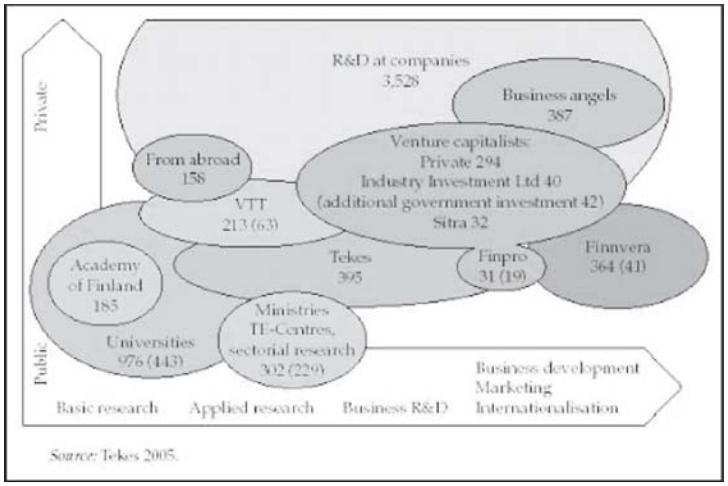


Figure - 8: S&T System in Finland: Resources and Funding

development of a sustainable knowledge-based economy.

5.4 High Quality Education: Key Element of a Knowledge-Based Economy: Education is the key element of a knowledge-based, innovation-driven economy. It affects both the supply of and demand for innovation. Human-capital and skilled labor complement technological advances. New technologies cannot be adopted in production without a sufficiently educated and trained workforce. The demand side is also important since innovations may not take place in the absence of educated and therefore, demanding customers and consumers.

In OECD's recent Program for International Student Assessment studies (PISA 2000 and 2003), Finland emerged at the top, in terms of learning skills among 15-year-olds in mathematics, science, and reading literacy. Other high-performers included Asian countries: Hong-Kong China, Japan, and Korea. What is unique in the Finnish case is the low variation among schools and across students. Significantly, the low-performing group did better than the average of the some 40 countries surveyed.

In the Finnish education-system, the local authorities are largely responsible for organizing basic education and schooling. Equality by gender, region, and socioeconomic background, are fundamental principles of the Finnish education-policy. Everyone receives the same basic education, and, furthermore, it is the goal of the educational system that no one relies on basic education alone. The social-security system in Finland also exerts a strong incentive for young people to continue educating themselves after the lower secondary school, which is normally completed in the age of 15–16 (Figure-9). One example of this is the requirement that a person must be 18 or over to qualify for unemployment benefits. Hence, there is an incentive to continue to go to school (free for everyone) after completing the lower-secondary education.

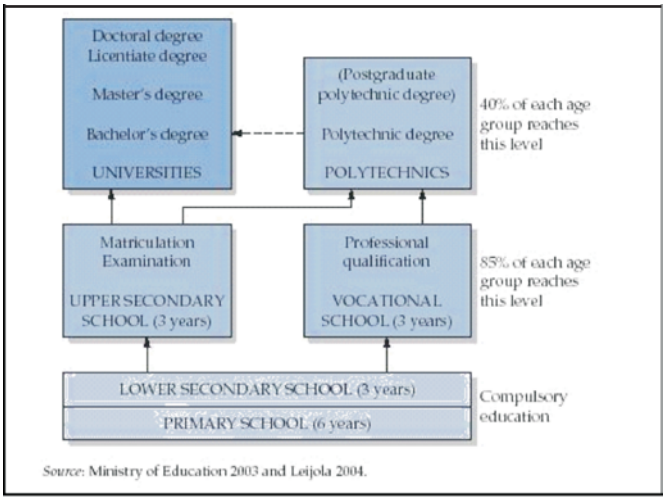


Figure - 9: Finland's Education Systems

Economic trends in higher education and the demand for certain skills have played significant roles in education policy. The expansion of the Finnish higher education system has followed and supported the course of economic development. Since the mid-1990s, the number of researchers in both the private and public sectors has risen faster than ever before in the country's history and ranks first in the world when compared to total employment (See Figure-10).

5.5 Challenges ahead for Finland: Clearly, the knowledge- and R&D-oriented, "high-road" strategy that Finland has pursued since the early 1990s has been one of the European and the world's success stories. Giving high priority to sound macroeconomic policies but gradually shifting the policy emphasis to microeconomic

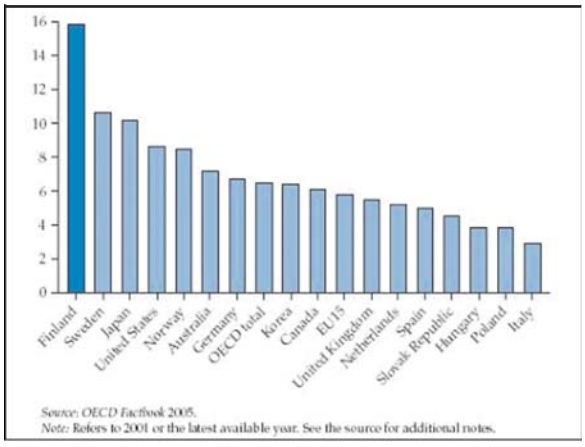


Figure - 10: Number of Researchers (per thousand employed)

policies has proved wise choices. After all, the competitive edge of an economy is created at the micro level: in firms, innovation and policy organizations, and educational institutions. Being one of the leading producers of a new generic technology certainly has created a strong competitive edge for the country. Consequently, many of the future challenges relate to ICT and the sustainability of competitiveness. Can the position gained be maintained?

The current competitiveness is not necessarily a guarantee of future growth. Across the world, competitiveness rankings seem to predict future growth relatively poorly. Many of the Asian countries that were ranked high in the early 1990s serve as examples. Continued success must be built on constant upgrading and renewal. It is the use of ICT—not necessarily its production—that is decisive for long-term economic growth. As the technology matures, the production gradually will spread to new locations. The ICT revolution is by no means over yet, but parts of both technology and service productions have started to relocate.

In Finland, productivity is the key to meet the increasing financing requirements of the welfare society. Due to Finland's relatively larger baby boom generations after the war, the aging of its population is proceeding somewhat faster than that of other European countries. The working age population (15–64) will start to decline before 2010.

This decline will have several consequences for knowledge-based economy's development, as well as for the whole society. On the one hand, the decline will provide opportunities to develop ICT-based welfare-services in the public sector. On the other hand, it implies a tough challenge to keep the productivity-growth fast enough. However, as the labor input of the aging-population declines, keeping up this growth becomes increasingly difficult.

The challenges for the near future are quite substantial as outlined in STPC's current Review of the Finnish economy (STPC 2000), which calls for:

- To enable the continuing growth of the Finnish ICT-cluster, with particular emphasis on the supply of skilled workers.
- To transform the entire society (including social, cultural and other sectors) into a knowledge-economy.
- To facilitate the growth of future clusters (to reduce the present dependence on the ICT-cluster).
- To enhance the transfer and diffusion of new-technology throughout society (to avoid creating gaps between modern and traditional sectors).
- To strengthen the science-base, with particular emphasis on the financing of university-based research.

5.6 Lessons to be learned From Finland's Experience: Finland has many specific characteristics that cannot be replicated easily by many other countries. One of these characteristics encompasses two attitudes: an independent spirit of self-reliance and a

"can-do" mindset that have been tempered by weather, geography, and occupations.

Another tempering factor is that since Finland has 60 percent of the world's population who live as far north as the Finns do, partly above the Artic Circle, over time, the very cold climate has created a very hardy population who must plan ahead to survive. The traits also may have been strengthened by its unique language, which is distinct from the other Nordic languages and which forms an exclusive bond among the Finns and differentiates them from others.

A third characteristic is a willingness to interact with the outside world, in an open but strongly nationalistic way. Perhaps because of the country's geographic isolation, Finns have a natural curiosity about the outside world that has made them very open to outside ideas and technology. Finns also were among the first to introduce electricity and to use the telephone. Similarly, they were very open to experimenting with different telephone-technologies, almost as soon as they were invented and to develop their own versions.

While several other characteristics may be somewhat unique to Finns, these three have been highlighted because they appear to be part of what has enabled Finland to build a successful nation state and, more recently, turn a major economic crisis into an opportunity and to transform itself from a somewhat marginal economy in Europe to the most competitive and knowledge intensive country in the world in less than a decade.

After the 1990s crisis, reforming the banking system and strengthening the capital-markets, including venture-capital, were important to make financing available for the growth of the new knowledge-intensive sectors of the economy, particularly the ICT cluster. Moreover, the financial and economic restructuring that took place after the crisis broke the traditional banking-led relationships including with Germany and Japan and led to a more dynamic and open financial system led more by stock market capitalization.

Clearly, all of these policies have been very important for Finland's success and may be considered necessary conditions, even if not sufficient, to explain its successful transformation into a knowledge economy. However, it should be re-emphasized that Finland's very strong early focus on competition in the telecommunications sector in particular was critical in laying the basis for a very dynamic sector and strong domestic capability.

The Nordic welfare-state with its strong social safety net and strong focus on free public education, was an important element of Finland's transformation. The social safety-net was particularly, important in addressing the jump in unemployment during the early 1990s crisis. The focus on retraining people and linking unemployment benefits to getting additional education also were very important in restructuring the economy toward high-technology industries. A special characteristic of Finland's

educational system, which differentiates it from the Anglo-Saxon Washington Consensus, is that education is free all the way up to the university-level. Other notable characteristics of Finland's education-system are its strong focus on equality measured by outcomes, tying welfare payments to training for young persons, tremendous openness; and focusing higher education on the needs of productive sector.

On a broader level, it is appropriate to reflect on what can be learned from the Finnish experience and what this implies for developing countries. The first lesson is that it is possible for a country to make a dramatic recovery in GDP and undertake a major restructuring, as Finland did. An important corollary is that a crisis can be turned into an opportunity. However, for this to happen, there may need to be certain preconditions as well as great flexibility in the economy.

Another special element was that there was a large conglomerate, Nokia, which was able to rise to the challenge. It is particularly noteworthy that, at the time of the crisis, Nokia was a large diversified conglomerate that had been growing through mergers and acquisitions. Besides feeling the effects of the general economic crisis, it was going through its own internal identity and management crisis. However, it decided to divest most of the traditional business and focus on the ICT sector, and mobile telephones in particular. Its success in making this transformation is legendary and hard to explain and ultimately probably has to be attributed to its new management.

A second lesson is that globalization is a double-edged sword and a demanding task-master. Finland's crisis in the early 1990s, in part, resulted from the global downturn of the forest related industry, as well as, the collapse of its trade with the former Soviet Union. Part of the solution to the crisis also resulted from globalization. The dramatic development of the ICT-industry is part of globalization. Finland's rapid growth in the ICT-area was possible because of globalization both in terms of (a) producing for a world market and (b) its ability to access the foreign-capital and knowledge that it required to develop the industry.

On the other hand, Finland is also struggling with the impact of globalization, which is putting pressure on it to improve its technology and education-system to stay competitive in a very demanding global environment. Finland still has an unemployment rate of nearly 10 percent. Finland is already doing better than most countries. All of Finland's concerns above emphasize just how much pressure globalization is putting on even the most competitive player.

The third, and perhaps the most critical, lesson is the importance of flexibility or elasticity of the economy, to react of changing opportunities. Finland's case aptly demonstrates the importance of this flexibility in the way that it was able to significantly restructure its economic structure as a result of the crisis of the early 1990s. Two critical aspects of that process of creative destruction were, the very strong social cohesion and strong safety-nets. However, it is perhaps the educational system

that has played the most critical role. The educational system was able to respond very quickly and flexibly to the new opportunities.

5.7 The Finnish Experience also has Several Implications for Developing Countries: The first implication is the continued importance of the basic elements of the Washington Consensus. These elements are essential to give the economies the flexibility they need to constantly redeploy assets to their most productive uses.

The second implication is the imperative to develop vision and consensus-making mechanisms. Reforms involve changing the status quo, and doing so usually does not happen unless there are major external or domestic forces pushing or demanding such changes.

The third implication is the importance of developing appropriate knowledge strategies, Finland had to increase higher educational attainment in general, and scientific and technical skills in particular. These challenges involved not only increasing R&D expenditure but also focusing on getting the fruits of R&D into the market. Finland's strong emphasis on the systemic approach to innovation evolved, including bridging the entrepreneurship and financing gaps to turn invention into commercial application.

These strategies have to be adjusted to the specifics of each country. For the majority of developing countries the focus needs to be somewhat different than Finland's. Because, in virtually all sectors, developing countries are still very far from the technological frontier, they still need to put priority on developing effective means of tapping the pre-existing and rapidly growing stock of global knowledge.

Developing countries need to put more weight than they do now on understanding, acquiring, adapting, diffusing, and using existing knowledge, including indigenous knowledge. This includes putting in place basic technological infrastructure such as norms and standards, metrology, testing, and quality control, as well as strong dissemination mechanisms and institutions such as technical information centers, productivity organizations, and agricultural and industrial extension agencies. In addition, developing countries need to set up public research institutes that can help them access what global technologies may be relevant and help them adapt these technologies to their circumstances.

More importantly, utilizing their existing knowledge also involves creating technological capability in their productive firms and in getting them to invest in improving and eventually creating their own technologies in their most advanced sectors.

Developing nations also will have to pay more attention to all levels of education. To the extent that many still have very low educational attainment, they will have pay more attention to strengthening universal basic and secondary education for their citizens to

become effective users of technology. They also will need to improve higher level secondary-education and even higher education, to keep up with and make effective use of the rapidly expanding technological frontier.

Developing an effective innovation-system also involves attracting FDI that can bring in relevant new technology to advance local economies. Attracting FDI also includes: getting into global value-chains, controlled by multinational companies and trying to move up those value-chains. It also includes developing linkages and networks between domestic public and private research-institutes and universities and foreign ones, as well as, among all of these domestic institutions.

A final implication for all countries is the importance of focusing not only on what can be learned from the past (their own and other countries' experiences) but on anticipating and preparing for the future. This is one of the key lessons of the Finnish example, which explains to some extent why Finland not only was able to make such a dramatic transformation to a knowledge-based economy, but also why it has been able to remain so competitive.

Moreover, as can be inferred from the challenges that Finland is facing as a result of the rapid advances in knowledge and the continuous challenge of globalization, the world is not standing still. What worked in the past may not work in the future, and the prerequisites for being successful seem to be rising ever higher and becoming ever more demanding. Thus, this derives the importance of looking forward to see to what extent it is possible, to be better prepared for future challenges and opportunities. Developing countries, in particular, need to monitor this aspect closely, because there may be important new areas that can be exploited, and it will be necessary for them to be ready to move to take advantage of them.

6. CONCLUSIONS

Developing nations have the choice to save themselves from the possibility of marginalization. This is possible only by their realizing the opportunity and aligning themselves toward transformation to knowledge-based economies. Knowledge, an asset that only increases when spread out or diffused, is the vital salvage for countries with limited natural resources. ICTs will keep playing their indispensable role and have to be channelized to their fullest capability in the developing world.

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DEVELOPING A KNOWLEDGE-BASED ECONOMY THROUGH CAPACITY-BUILDING IN SCIENCE AND TECHNOLOGY

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1. INTRODUCTION

The last decades of the 20th century have been a great turning point for the global development process. For the last two hundred years, neo-classical economics has recognized only two factors of production: labor and capital. This is now changing, information and knowledge are replacing capital and energy as the primary wealth-creating assets, just as the latter two replaced land and labor 200 years ago. It is knowledge that has become the engine of the social, economic and cultural development in today's world. Knowledge-intensive economic activities are now a factor of production of strategic importance in the leading countries. They have also become the main indicator of the level of development and the readiness of every country for a further economic and cultural growth in the 21st century.

The industrial revolution in the 19th century and scientific revolution in 20th century have developed conditions for the growth of knowledge-based economy. Economic activities associated with the production and utilization of information and knowledge have become the creators of economic growth in the market economies of developed countries, increasingly transforming all the other dimensions of development and the entire ways of living in today's world.

2. KNOWLEDGE-BASED ECONOMY - A BROAD PHENOMENON

The knowledge-based economy is a much complex and broader phenomenon. There are different dimensions and aspects of the knowledge-based economy:

Information and Communication Technologies: Information and communication technology (ICTs) is a very powerful technological driving force for a knowledge-based economy. ICTs are growing rapidly and there appears a new generation of ICT every three to four years. Today, the ICT-companies are among the largest corporations. The ICT-sector is amongst the fastest growing economic sectors.

Telecommunication and Networking: The information-society has become a reality It is a part of every aspect of our lives. Telecommunication and networking, along with a rapid growth of ICTs have penetrated all the spheres of human activity, forcing them to work into an absolutely new mode and creating new spheres.

Knowledge: Knowledge, based on information and supported by cultural and spiritual values, is now an independent force and the most important factor of social, economic, technological and cultural transformation.

Societal Aspects: The knowledge-based economy affects other areas of societal activity as well in every country, like institutional and innovation system, human-resources development, etc., and vica versa. If a country is developed; it has a developed knowledge-based economy, if a country is lagging behind; a knowledge-based economy constitutes just a small fraction of its economy.

3. IMPORTANCE OF SCIENTIFIC AND TECHNOLOGICAL CAPACITY IN KNOWLEDGE-BASED ECONOMY

Science and technology have become a pillar of knowledge-based economy and a fundamental catalyst for economic development. Science ultimately supports the innovations and concepts that meet societal needs and drive economies. Many developing countries are still in the process of eliminating poverty by providing proper nutrition and suppressing diseases that deplete a population's strength, confidence and ability to earn. Appropriate application of technologies of broad international interest can improve many aspects of social and economic development, from pest-resistant crops to less wasteful food processing; from prenatal care and child health to the prevention and treatment of diseases; from reduction of environmental contaminants to purification of water; and, from more reliable electricity to more efficient and affordable communication and transportation systems, everything can be improved.

3.1 Revolution in the World Through Science and Technology

The countless manifestations of science encompass our world, and intensely affect the social, economic, and cultural outlooks of societies and individuals alike. Moreover, the accumulation of scientific knowledge and its technological applications is accelerating at a fast pace. The Internet, for example, transforms the very meaning of time and space. With a click of a mouse, various important tasks take place across the globe. Today, one can find smallest possible information on the World Wide Web. Thus, the integration of the world economy through trade, capital flows, and enhanced communications is rapidly proceeding as the products of the ICTs revolution permeate every corner of society. A revolution is occurring in the life-sciences as well. Better health care, nutrition and clean living environment provide the younger generation of developing countries an ability to attend school and to complete more years of schooling. This results in a major increase in the number of people who have far better prospects of contributing to the overall welfare of society and of leading more satisfied lives.

However, the global reality is that many innovations fail to benefit those who need them most, and are not shared equally around the globe. Such unequal distribution is

further intensified by troubling trends in demography, urbanization, public health, and environment, which will continue in the foreseeable future.

3.2 Importance of Local S&T Capacity

Leaving all of the scientific and technological breakthroughs to the highly industrialized nations and expecting the rest of the world to benefit from the results is an illusory and unproductive policy. The tools involved in such breakthroughs are often very sophisticated and their use requires a great deal of knowledge at the local level, as well as an ability to adapt and extend them to meet local needs. Moreover, collaboration among developed and developing nations is needed to address many global issues such as biodiversity loss and climate change.

A general matter is the recognition of the need for domestic S&T capacity in developing countries. Contrary to prior hopes, the advances in industrialized countries have not been automatically or easily applied to the problems of the developing world. By building local STI capacity, developing countries can not only better absorb and adapt foreign technologies, but also develop local solutions to local problems.

While implementing the successful technologies of the developed nations in developing nations, it is important that the highly developed nations provide a combination of capital and know-how to help people in the developing nations acquire, understand, and effectively apply these scientific and technological tools. The S&T-proficient countries can also fill a particularly useful niche in this regard. They can utilize some of the lessons learned from their own evolution. For instance, to help train young scientists, engineers, and medical professionals of S&T-lagging countries in critical fields.

A fundamental reason for global cooperation is that the world is undergoing such a huge transformation that its consequences can barely be imagined. All developing countries are passengers of the same ship, facing major challenges together as they sail into the unknown, and insights from all of their cultures and people are essential.

Some local institutions place obstacles in the path of much needed S&T reforms which might result from misperceptions - that S&T will be expensive propositions or that basic science is a luxury that poorer countries cannot afford. Some obstacles are created by fear of the potentially disruptive consequences of free-ranging inquiry and expression, which can threaten (or appear to threaten) the religious foundations, as well as the secular ideologies of various societies. Other barriers result from science and technology being seen as synonymous with types of modernization, which some local leaders believe will disrupt the continuity and integrity of well-established cultural patterns. Still others reflect fear of the economic and social costs of technological transformations in production.

It is very important for S&T capacity-building that the S & T organizations engage the reluctant parties, solve their concerns and focus on proper utilization of S&T, in order to eliminate problems of developing countries. However, to achieve the desired goals the need for a strong political will, less bureaucratic administration, a change in the mindset of the S&T community itself, and committed resources is necessary.

3.3 The Cultural and Social Aspect of Science

The culture and values of science are critical for building a global community. Science is not only a culture of global dimensions but itself, it induces a cultural current that strongly and positively affects societies in which it flourishes - including those that were first wracked by poverty and hunger, driven by civil strife, and embedded in fiscal crisis. Science brings imagination and vision to bear across the board - on theoretical speculations as well as on practical problems and critical decisions. It allows people to analyze present and future situations, make sounder choices, and invest their resources more wisely. The culture of science and the open, honest values that it engenders are enormously important for the above-mentioned aspects, beyond the material benefits that they produce for human welfare.

Science and its practitioners should be constantly engaged in a dialogue with society at large. Not only will this benefit the decisions of society, by bringing to bear the outlook and knowledge of scientists in the decision making process, but it will also help science to recognize the non-scientific aspects of decisions that affect scientific research and the deployment of its products. Through this dialogue of science and society, society will gain a scientific outlook while science will gain a new social contract.

3.4 Investments in S&T

Investments in science and technology are increasingly important for economic growth. When national research and development activities are taken as a whole, it is seen that the high-income industrialized nations - Australia, Canada, Japan, South Korea, the United States, and northern and western Europe all spend between 1.5 percent and 3.8 percent of their GDP, on research and development. While developing nations with large economies have approached the lower-end R&D/GDP ratios of OECD countries (for example, India allocates 1.2 percent; Brazil, 0.91 percent; and China, 0.69 percent), most developing nations devote less than 0.5 percent of their GDP to research and development. National governments in developing nations should increase their spending considerably, certainly above 1 percent of GDP and preferably closer to 1.5 percent, in order to improve their conditions and develop further.

There are many examples of successful economies, such as those of the 'East Asian Tigers', who have achieved much by focusing on education and investing in research and development. The figures from South Korea (2.55 percent), Taiwan-China (1.97 percent), and Singapore (1.47 percent), and the considerable material benefits

accruing to the people of those countries, are renowned stories of success.

3.5 An Ever-growing Gap Between Developing and Developed Nations

The industrialized and scientifically and technology advanced countries certainly have concerns about balancing the public and private domains, improving the quality of their educational systems, attracting and retaining talent in S&T fields, or the manner in which national investments in research and development (R&D) can be optimized. The starkest problem facing the world and the international scientific community is the large and growing gap between the industrialized nations and the less-developed countries. As we move toward a knowledge-based economy, some 80 percent of humanity is still deprived of the opportunity to contribute to knowledge and are instead consigned to consumption of the resulting technology. Furthermore, it is not possible for developing nations to consume new technologies without a powerful local capacity in S & T underlying them.

In fact, a fierce cycle is at work whereby the developing nations (especially the S&T-lagging countries) fall farther and farther behind the industrialized nations that are proficient in creatively utilizing scientific advances and new technologies and have the resources, in financial, as well as human-development terms. Another problem is of young professionals from developing nations who emigrate or remain in the industrialized nations where they may have received some education and training, instead of applying their skills at home, where the need may often be the greatest but prospects for present-day opportunities the worst. This dilemma of 'brain drain' is actively involved in diminishing some of the developing nations' human resources and it is getting worse as the populations of wealthy countries get older, more people retire, and attractive employment opportunities arise there.

3.6 Cooperation Between Developing and Developed Countries

Growth of science and technology helps in building markets, promoting stability, and enhancing trade. One of the reasons which makes developed nations interested in supporting the development of S&T capacity in developing world, is that their citizens cannot flourish and remain safe, when a large number of countries are in worse conditions. Developing countries can get best out of S&T by creating local capacity along with the cooperation of developed nations. In addition, the developing nations such as Brazil, Chile, China, India, Mexico and South Africa which are more proficient in S&T should work with their fellow developing countries so that they too, may build their S&T capacities.

3.7 Societies Resistant to Science and Technology (S&T)

Despite the remarkable results that scientific advances and technological innovations can potentially produce, present times are flawed by conflict, violence, economic uncertainty, chronic deprivation and poverty, even threatened lives. Although we

know that S&T can indeed help feed the hungry, heal the sick, protect the environment, provide dignity in work, and create space for the joy of self-expression, under-developed societies lack the resources to apply them.

Regardless of reservations of some cultures the activities of scientific and technological research and development will continue to move forward, because of the benefits that can be obtained. These barriers can be removed and the minds of doubters can be relieved by working together .The challenges can be faced, depending on a nation's ability to help guide and quicken the ways in which development might proceed, so as to achieve the positive goals.

3.8 Fundamental Role of Universities in Building S&T Capacities

The major focus of scientific research in many countries is located within the organizational framework of universities. Research performed within universities has an added value because of its beneficial effects in raising the level of education provided to the professionals who are trained there. However, in many of the developing nations, higher-education systems are subject to massive social and political pressures to increase their enrollments. These factors play a major role in reducing the quality and ability of universities to play the role that is expected of them. There are many institutes that have succeeded in bearing the political pressures and have also expanded enrolments as well, while maintaining international standards.

A university in any developing country plays a special role as a source for creating awareness in the society, promoting the 'values' of science, and mediating between the political and industrial spheres of a nation's life. The universities' research facilities should be such that they orchestrate the brainpower of the faculty, participate in the transformation of the nation's S&T base, and take the responsibility for training new generations having talent. Unfortunately, the current structures of higher-education systems in many countries are not up to the required standards. Since universities are the center-piece of any human-resource development strategy for S&T capacity, wide-ranging reforms are needed.

In particular, the promotion of special world-class research programs in universities is essential for meeting the challenge of building capacity for S&T. Such research programs should have a great degree of autonomy and should develop and exert their influence in the short term, even while the needed reforms of the entire system proceed over a long-term horizon.

4. ACADEMICALLY STRONG UNIVERSITIES ARE IMPERATIVE FOR BUILDING NATIONAL CAPACITIES IN S&T

Universities are very important for the development of countries' S&T capacities. They educate and train new generations having scientific and technological interest who can perform research on issues of importance to the nation, and provide an

independent source of information on such topics as economic development, agriculture, health, and the environment. National governments in developing nations should make a clear and continued commitment to support and encourage advanced education and research activities within universities, in collaboration with independent research institutes and industries. Without such an explicit national commitment to strengthen universities, critical mass in the country's S&T simply cannot be achieved. An example of a very successful and academically strong university of the world is given below:

4.1 National Autonomous University of Mexico

The Universidad Nacional AutÃnoma de Mexico (UNAM) has been subject to all the demographic and political pressures experienced by public universities in many other populous developing countries also. Yet UNAM has succeeded in maintaining centers of excellence according to the highest international standards. Despite having over 150,000 university-level students, UNAM research is at the cutting edge in several areas and is developing programs related to industry. UNAM graduates has the largest number of doctoral-degree holders in science and engineering in the country and has filed the second-largest number of patents (after the Mexican Petroleum Institute). UNAM maintains a 'hands-on' science museum, managed by faculty members and science students, which receives annually over one million visitors (the majority being youngsters). To ensure that the university's research work and graduate programs are at the highest level, scientists from the United States and Mexican academies of sciences were enlisted to review them. While the joint review was favorable, the university seriously took action upon the committee's recommendations for further improvement in performance.

In order to build S&T capacity in a proficient manner university reforms should take the following necessary actions:

- *Academic Policies and procedures:* In order to develop the younger talent, merit-based academic policies and procedures should be strengthened, so that youngsters can gain intellectual independence by climbing the academic ladder.
- *Academic and Governance Structures:* To remove barriers for change and for conducting interdisciplinary and transdisciplinary research, academic and governance structures should be remodified. This reform should include promotion of an interaction of the physical, biological, and earth scientists with academicians in the humanities and social sciences.
- *Evaluations:* Regular evaluations followed by up-gradation of university departments, institutes, and faculties by external reviewers, including international experts, should be promoted.
- *Funding:* Higher-education needs to be strengthen by national governments in developing nations with the help of public funds (supplemented with private funds if available) to offer better opportunities for tertiary education and S&T

training to young people in modalities ranging from 'community colleges' to top-class research-based universities.

- *Partnership:* It is very crucial to develop a strong partnership between National governments in developing nations and universities and industry to plan the development of capabilities in S&T.
- *Collaboration with regional and international organizations:* In order to develop effective S&T capacity universities should have increased autonomy while seeking to systematically strengthen their ties with regional and international institutions and networks.
- *Commitment to excellence:* Along with greater interaction with society, research universities should make strong commitments to excellence and the promotion of the values of science in their activities, incorporating unbiased merit review into all of their decisions on people, programs, and resources.
- *Transparent and rigorous systems:* It is very crucial for post-graduate programs to establish transparent and rigorous systems of institutional and program accreditation at the national and international levels.

4.2 Building Capacity in Agriculture, Engineering, Health, and the Social Sciences is Essential for National Development

S&T, encompasses a wide range of fields and disciplines, including aeronautics and astronautics; agricultural sciences; anthropology; biology; brain and cognitive sciences; chemical engineering; chemistry; civil and environmental engineering; earth, atmospheric, and planetary sciences; economics; electrical engineering and computer science; systems engineering; health sciences and technology; materials science and engineering; mathematics; mechanical engineering; nuclear engineering; physics; political science; psychology; and sociology.

The areas of agriculture, engineering, and health, however, appear to become the most important in addressing the challenges of developing nations. The study of agriculture, engineering, and health is closely related not only to research but to practice as well. Therefore, the training institutes and the types of research institutes, such as teaching hospitals, agricultural research centers, or S&T parks linked to university complexes or located nearby, are somewhat different and valuable from the more standardized image of scientific laboratories and academic departments.

Although the social sciences differ from the physical, biological, and mathematical sciences in their focus on human behavior, the development of social-science capacity should be given equal importance. The role of well-trained and insightful economists, sociologists, anthropologists, political scientists, public-administrators, and other social-science professionals is especially important in providing policy analyses, developing the S&T culture, building institutions, and maintaining the public-private interface for S&T promotion.

Building capacity in agriculture, engineering, health, and the social sciences is very

important for national development. In the developing world especially, the need for problem-solvers working together in interdisciplinary and systems-level fashion is important.

4.3 Human-Resource Development

While leaders of nations mostly address the issues such as cure for diseases and improving quality of life, very little is said about the development of human resources which is in reality the main route for achieving these goals. In order to attain development in developing countries a lot needs to be done for a nation's human resources, especially its S&T professionals. Steps like the creation, maintenance, and constant upgrading of the educational base, from primary school to university level; training new generations of scientists and engineers, as well as others among the nation's future leaders; generation of technological innovations; capability to access and productively use new technologies; full participation, as equal partners, in international initiatives, designed to solve global problems should be taken.

If the developing countries intend to achieve a knowledge-based developed economy, it is necessary that national policies and international support focus on a key set of prerequisites, i.e., the right kind of people should be trained in sufficient numbers to do the job. Moreover, incentives should be provided, such as high-quality working conditions, to retain them in their home country. Nothing is more important then satisfied employees at organizations, satisfied students at universities and, satisfied citizens at homes, thus, leading to a stable environment in a country. It is very important to give first priority to national competencies for bringing about sustainable development in each country.

4.4 High-Quality Education and Training are Essential for All Nations

As majority of the problems being faced by humanity are solved through S&T it is the very important that S&T be made the main part of education system. Courses providing the basis of S&T literacy and reasonable familiarity with scientific and technological culture should be included at all levels and for all students, including those who do not intend to specialize in science or engineering. Education will not achieve the required standard unit unless the number of teachers proficient in science and technology and the quality of their education is increased. Also S&T literacy and culture need to be imparted in such a way that the interest and imagination of young learners is captured. In many countries there is a dire shortage of such teachers who are unable to keep up with constantly evolving S&T developments, even if their formal training was first-rate. This results in a difficulty for them to provide up-to-date knowledge to their students or in fruitfully applying the most recent teaching innovations. As a consequence students often become bored or discouraged; even those few who would specialize in science or engineering may shift to other fields, thus reducing their interest in learning. This is why developing countries do the not have enough qualified scientists and engineers, qualified teachers, or 'S&T-qualified

citizens' coming out of the academic system. Much more serious actions can be taken to remedy the situation. Such projects can be launched by S&T-related academies and societies that pair active researchers with teachers in elementary, middle, and high schools in order to facilitate learning. Another set of activities which can be done, is arranging national and international contests for students on mathematics and science subjects.

Now a days the private sector is also taking initiatives to improve S & T education, as companies see that it is in their interest to improve the S&T education of people in whose communities they operate; this makes for better community relations and a larger and more capable labor pool from which to draw. Some of the organizations involved in such activities are following:

AES Gener: Programa Amigos de la Ciencia (Friends of Science) is a Chilean educational project financially supported by AES Gener, the Chilean branch of a privately owned electric-power company. Since 1995, over 40,000 children from impoverished backgrounds have participated. During 90-minute workshops held in factory offices some 40 weeks a year, students are guided to learn by discovery through a carefully designed sequence of activities. Through this program, children can acquire new abilities and learn concepts and fundamental principles of different scientific disciplines.

Dow Chemical Company: The aims of Dow's science-grants program are to improve mathematics, science, and technology education; upgrade teacher training and development; and increase parental involvement. The company focuses on school districts and boards in Dow-factory communities rather than on individual schools, and on programs that promote systemic educational reform. The company also pursues projects with key strategic partners, such as one with the U.S. National Science Resources Center where Dow gave financial assistance to 42 school districts for the organization of science centers, dissemination of new science-curriculum materials, and teachers' professional development.

Hewlett-Packard Company: Hewlett-Packard reports that in 2001 alone it 'contributed more than $54 million in resources worldwide to advance the ability of students, teachers, community residents, and non-profits to solve some of their most fundamental challenges.' The company's programs sponsored the attendance of five U.S. school-district teams ranging from kindergarten to grade-8 from low-income, ethnically diverse communities, at the National Science Resources Center Institutes (NSRCI); supported the Institute for Women and Technology's Virtual Development Centers (VDC); built 'digital villages' in two communities in Ghana and South Africa; and recognized some of the Asia Pacific region's most promising minds through Young Inventors Awards.

Sony Corporation: At the time of Sony's establishment, founders Masaru Ibuka and Akio Morita wrote that introducing science education into elementary schools was the

key to rebuilding Japan in the aftermath of World War II. This belief guided the establishment of the Sony Foundation for Education, which has offered financial support for schools and teachers over the past 42 years. The Foundation's Science-Education Program for Children funds elementary and junior high schools and teachers throughout Japan, especially those who are enthusiastically fostering interest in science among children. Recently, Sony began providing assistance for public elementary schools in Mexican communities. In another program, Sony provided support for a project in South Africa called School TV Access, which is run by the South African Broadcasting Company.

It is essential to strengthen the capacity of universities to admit aspiring young scientists and engineers from around the world. Institutions of this type in the developing nations can especially play an important role the region where they are located. Another benefit they can bring is the cooperation among them which can lead to networking among their best researchers at national, regional, and international levels which can help educate the most promising students and provide fellowships for them. Since these are the graduates who will later be important for building the S&T capacities of their own countries, support for their work and professional development is essential.

S&T education should not be restricted to aspiring scientists and technologists or just to students. In addition to including S&T culture courses in formal education the culture should be imparted to non-student public through pathways such as radio, television, internet, print media, science museums, and community-development projects. In this way, the public can become sensitized to the important role of science and technology in society and their potential to help solve urgent problems.

5. DEVELOPING, ATTRACTING AND MAINTAINING S&T TALENT IN DEVELOPING COUNTRIES

Many developing nations have to undergo two severe human-resource shortages; firstly, an insufficient number of highly qualified scientists and engineers at universities and second research institutions; and secondly a shortage of well-trained S&T teachers in the colleges and secondary and primary schools. One of the major reasons behind these persistent problems is the difficulty of keeping locally trained talent at home, as well as of attracting home those individuals who have obtained their degrees at foreign institutions. The brain-drain issue is a serious obstacle for building and sustaining human-resources.
Among the various reasons for brain-drain, some of the common ones between the developing countries are as follows:

- Highly uncertain socio-economic conditions for the future.
- Poor working conditions, including the lack of basic instrumentation and technical support
- Inadequate salary packages

- Low probability of attaining a sense of self-fulfillment ; scientific, cultural, or financial;
- Limited prospects for belonging to research groups that are recognized by, and well connected to, the worldwide S&T community;
- Little or no R&D in the public and private enterprises themselves;

In order to reduce a developing nation's brain-drain problem improvement in any of the above elements would certainly be useful in its own right, but all of them should be on a nation's agenda. In order to achieve success in accomplishing such progress depends, on understanding the complex nature of the problem's fundamental causes in the national, regional, and global contexts.

There are some nations such as the 'East Asian Tigers' who have been relatively successful in addressing such basic problems, they have not only been successful in retaining talent but they have also managed to enlarge, their pool of S&T-competent nationals. Moreover, they have often provided stimulating ambiences for these individuals' research, and given them incentives not to look abroad, in two productive ways: by promoting targeted initiatives in commercially promising areas of S&T such as information and communications technology (ICTs); and by facilitating the collaboration of governmental, academic, and industrial scientists and engineers for ultimately generating innovations in the country's products and services. (Source: Inventing a Better Future 2004: Inter Academy Council)

Acknowledging and appreciating young talent as well as joining the world wide science community without leaving homes is especially important. Not only is the reward in attracting, cultivating, and retaining bright young talent great but self-perpetuating too they are ultimately bound to become leaders who help change local mindsets and create awareness about the importance of S&T for sustainable development. Some other ways to address the problem of brain drain include collaboration programs between developing countries and their expatriate scientists/ engineers and increasing financial and technical support.

One large group of talent which can act as a major portion of capacity building is usually ignored in developing countries. More than half of most countries' populations' i.e. their women are traditionally overlooked for important jobs or are deprived of the education needed to make them even nominal contenders. Achieving greater participation of women should be a major goal in building S&T capacities, because societies simply cannot allow themselves to be deprived of the abilities and potentialities of women.

In order to build up and retain S& T talent a developing country needs to bring almost the following changes:

- *Financial support:* National governments and international organizations should provide the financial support and design such an institutional framework that establishes such university programs which provide for study

in, and return from, a more advanced S&T country. These should have the following key characteristics:
  - Competitive selection processes,
  - Concise program objectives,
  - Efficient monitoring and communication between advisers and participating institutions at home and abroad.
- *Opportunities for best S & T talents:* Governments of developing countries, should consider providing, even on a temporary basis, special working conditions for their best S&T talents (whether formed at international programs abroad or at home), including income supplements and adequate research support. These programs should primarily focus on young scientists and engineers, enhancing future leadership, which can ultimately improve working conditions for all of its scientists and engineers.
- *Encouragement of organizations by Government:* Companies should be encouraged by providing them with incentives, to create in-house research units and hire S&T talent. Local governments can give them tax rebates or national recognition for building their human-resources capacity in S&T (through internship programs and contracted research).
- *Coordination with expatriates:* Governments of developing nations, in collaboration with their national S&T communities, should establish ties with their expatriate scientists and engineers, especially those who are working in industrialized nations.
- *Incentives for outstanding researchers:* Governments and private institutions in industrialized nations should provide incentives for outstanding young researchers from developing nations to apply their skills in the service of their native lands.
- *Capacity building of females:* The S&T community should develop outreach programs to:
  - Provide scientific knowledge to girls during their early childhood;
  - Provide female scientists and engineers with flexible working hours and opportunities for part-time work during their family-raising years;
  - Allow women who wish to leave their jobs for purposes such as child-care to rejoin at a later date.
  - Extend the periods during which critical stages of one's career like doctoral research or the seeking of tenure, for example may occur
- *Ethnic, gender, and cultural diversity:* Special programs should be promoted by the S&T organizations for assuring ethnic, gender, and cultural diversity. Such programs should apply to all phases of the 'pipeline,' from early childhood through graduate school and into professionals' working lives.
- *Trends in international migration:* Appropriate international organizations should compile reliable global and national statistics documenting trends in the international migration of scientists and engineers.

6. CREATING WORLD-CLASS RESEARCH INSTITUTIONS

Science and technology (S&T) capacity building in institutions is a long term investment to develop a knowledge-based economy. Developed nations over centuries have succeeded in creating a number of institutional mechanisms that together have evolved into a complex of mutual support for S&T. An institution of international standards commits to an educational system that promotes an appreciation of S&T and a respect for rationality and the values of research. It comprises of a system of universities and research centers; independent academies of sciences, engineering, and medicine as well. Ministries or equivalent executive-branch structure are available for guiding decision making on matters of S&T policy. Professional and other associations serve the practitioners of various disciplines. In such world class institutes public funding mechanisms for promoting public-goods and fundamental research are available while private funding mechanisms, such as foundations are also active. Similarly many other facilities are available at these international institutes which make them world class.

While industrialized nations usually possess such institutes, many developing nations lack them and need to correct such deficiencies. Unless developing nations particularly the ones lagging more in S&T, acquire such institutions along with suitable mechanisms for their effective interaction, it will be very difficult to promote S&T capacity, and to achieve sustainable form of economic development.

6.1 Centers of Excellence to Address Local Challenges

Centers of excellence are a great place (where research and advanced training is carried out, often in collaboration with other centers, institutions, and individuals) for the advancement of S&T. Most of them are located at successful universities that tend to win most of the competitive research grants or in national laboratories. Centers of excellence are the key to innovation, and their importance cannot be overstated. For example, in the United States, with over 4,100 colleges and universities the top 100 universities account for US$22 billion of the overall US$27 billion in academic research expenditures.(Source : inventing a better future: Inter academy council).

Korean Centers of Excellence: In Korea, centers of excellence are designated and supported by the Ministry of Science and Technology. These include Science Research Centers, Engineering Research Centers, and Regional Research Centers, intended to serve as major tools for promoting research and development in universities. The Science Research Centers focus on new theories in basic science and in-depth research on natural phenomena; the Engineering Research Centers emphasize development of highly advanced industrial technology; and the Regional Research Centers stress cooperative research between regional universities and industry. The Science Research and Engineering Research Centers are selected on the basis of research quality, skills, and capability; the Regional Research Centers are chosen to achieve balanced regional development of academia-industry cooperation in R&D. To

ensure the continuity of their research activities, these centers receive government funding for a period of nine years, provided that periodic evaluations (conducted every three years) show good progress. The result is that the centers, which are considered one of the most successful research programs in Korea, have significantly raised the research profiles of the selected universities. Each center consists of about 10 faculty members and receives some US$1million per year for the nine-year duration. Since they are all part of universities, the centers are open to foreign students. (Source: inventing a better future: Inter Academy Council).

For the S&T capacities of developing nations to grow, developing nations should also have centers of excellence whether of local, national, regional, or international status. Such programs should have the following characteristics:

- *Essentials for Centers of excellence:* The centers of excellence should have sustainable financial support ,institutional autonomy, knowledgeable and capable leadership, international input, focused research agendas that include interdisciplinary themes, applied research, as well as basic research, technology transfer, peer review as a systemic element, merit-based hiring and promotion policies, and mechanisms for nurturing new generations of S&T talent.
- *Personnel, infrastructure, and research at Centers of excellence:* Each developing nation should plan research programs, within a university, a research institute, or operate independently, typically in one geographical location, with highest international quality in personnel, infrastructure, and research output whether of local, national, regional, or international status. Such centers can serve as the main nodes for individuals or groups charged with enhancing S&T knowledge of national and regional importance.
- *Reformation:* Already existing institutions should be reformed up to the desired requirements.
- *Expert merit review:* Whenever new scientific and technological research projects are to be started, it should be decided on the basis of input from expert merit review, with each project and program evaluated for both technical merit and its potential benefits to society. Existing research programs and centers of excellence can also benefit from periodic expert merit review and evaluation. In some developing nations experts from developed countries can conduct reviews to make them more effective.

7. VIRTUAL NETWORKS OF EXCELLENCE TO LINK THE SCIENTIFIC TALENTS OF ENTIRE REGIONS AND THE GLOBE

Traditional centers of excellence are crucial for developing nations, but in order to expedite evolution of S&T capacity they should be complemented by new structures. An important step in this direction is creation of 'virtual networks of excellence' (VNE) throughout the developing world. Virtual networks of excellence (VNEs) will mobilize groups of scientists and engineers to collaborate on projects and develop S&T talent largely through 'virtual institutes.' Virtual institutes should be designed to be relatively

small, efficient, and embrace innovative research groups anchored in recognized research centers. These groups will be connected to each other via internet even if they are geographically located very far to each other. The virtual institutes created through VNE will work to blend their activities into coherent programs, while the individual research groups will work in areas of prime interest to their own countries.

A VNE-sponsored virtual institute is supposed to fulfill objectives such as:

- Establishing ways to transfer generated knowledge to the public and private sectors, thus helping to solve important social problems and improve the competitiveness of the country's industries
- Deepening competence in important areas of S&T through broad national, regional, and international activities;
- Contributing to solutions of global problems that could have significant impact on the country;
- Promoting regional S&T partnerships;
- Helping in the professional growth of talented young researchers.

With these objectives each virtual institute is supposed to be coordinated by a researcher of exceptional repute who is responsible for its research efforts and administration. Although the resources for establishing a VNE can be extensive, the benefits will be worth the costs to investors and beneficial to developing world as well. Virtual networks of excellence are a convenient way today to mobilize scientific and technological communities because of modern communications, wherever they are for addressing issues of national, regional, or international interest.

8. MILLENNIUM SCIENCE INITIATIVE (MSI)

An important instrument in the promotion of virtual networks and, in some cases, centers of excellence, is the Millennium Science Initiative (MSI). The MSI, with major funding by the World Bank, seeks to strengthen S&T capacity in developing countries. It supports locally planned and executed programs that provide new opportunities for talented scientists to excel through research, training, networking, and outreach. Core qualities of the MSI include autonomy, flexibility, objective selection and evaluation, and adequate and sustained funding. Local leadership helps ensure continuity, political acceptance, and familiarity with local challenges. The successes of MSI programs in Chile, Mexico, and Brazil have shown that even limited investments in programs designed to reflect international 'best practices' can have a an undoubtedly large impact on a nation's performance and productivity in S&T. To promote MSI all over the developing world, the Science Institute Group (SIG) was created to serve as facilitator and catalyst for the program in each country or region.

- *Brazilian Millennium Institutes*. Two groups of MSIs have been established in Brazil through competition: Group I includes 15 S&T institutes that could play key roles in achieving new standards of national competence in their fields, which range from mathematics to nanosciences to tissue bioengineering to the

effects on climate of land-use changes in the Amazon. Group II includes two institutes that operate in broadly defined strategic areas - namely semiarid-region research and coastal research. These institutes are financed by the Brazilian government and the World Bank in equal parts, with initial backing from the MSI.

- *African Millennium Institutes*. The African MSI focuses on three areas - biotechnology, instrumentation and information technology, and mathematics - chosen on the basis of present strengths and potential for maximum benefit to the region. The emphasis in each scientific area is on research and training, some of it through virtual means, involving institutions, researchers, and students distributed across the continent. This project has been driven by the African scientific community from the start, with institutions elsewhere playing supportive roles. (source : Inventing a better future:www.msi-sig.org/sig.html)

9. NATIONAL ACADEMIES OF SCIENCES, ENGINEERING AND MEDICINE CAN IMPROVE THE QUALITY OF NATIONAL S&T PROGRAMS

National academies are member-based autonomous institutions, in which new members are elected by peers in recognition of their distinguished and continuing professional achievements, elect their own officials, perform programs of independent work, and inform the general public and national decision makers on S&T aspects of public policies. Every country should have national academies of sciences, engineering, and medicine because presence of such institutions is extremely important for upholding the quality of S&T activity in a country, for guiding national policies based on S&T, and for maintaining a dialogue with other countries, often through their counterpart academies.

For those countries without a critical mass of active scientists or engineers, the creation of national academies may not be possible. In such cases, academies should be built on a regional rather than a national basis. The formation of professional societies should also be promoted.

International institutions, such as the Third World Academy of Sciences (TWAS), InterAcademy Panel (IAP), International Council for Science (ICSU), Council of Academies of Engineering and Technological Sciences (CAETS), and InterAcademy Medical Panel (IAMP), play a crucial role in facilitating the formation and strengthening of emerging national and regional academies of sciences, engineering, and medicine. The forceful participation of these international bodies helps new organizations in establishing the requisite high standards and effective mechanisms of operation.

10. ROLE OF PUBLIC AND PRIVATE SECTORS IN BUILDING CAPACITIES

For-profit organizations - propelled in large part by the globalization phenomenon

that favors the fast, the nimble, the businesslike, and the educated - have now become the world's predominant force in applying science and technology (S&T) to the production and distribution of new goods and services. In 2000, the private sector's share of investments in research and development worldwide was 62 percent.

Although the private sector in the developing world does not yet significantly contributes to research and development its dominance is likely to continue and expand in the foreseeable future. Actually, the fact is that in many developing nations the most important entities involved in research and development are publicly owned for-profit entities, which frequently have the capacity to become viable partners in ventures of research and development and are quite competitive in regional markets.

The private or public development sectors are equally important to the economic growth of developing nations: their activities create greater employment opportunities for skilled workers, along with increased demand for scientific and engineering education. A successful mechanism of these sectors can create more entrepreneurship, additional products and services, increase in employment opportunities, and a consequent demand for more knowledge.

11. PROMOTION OF PUBLIC AND PRIVATE INTERACTION THROUGH COMPREHENSIVE LEGAL FRAMEWORKS

Globalization results from numerous agreements between sovereign nation-states that are the principal actors in international, legal and financial systems. State-sanctioned isolationist impulses, by contrast, can result into disaster for a country's citizens as its S&T capacity, and hence its competitive position and economic health, wither on the vine.

It is essential to recognize that the public sector should maintain an environment which facilitates the private sector to keep on contributing to the development of S&T capacity. Meanwhile, governments should provide such regulatory frameworks that protect the public interest and safety, and fund R&D efforts for public goods. It is important to define a framework for public-private interface so that each party is sufficiently aware of its domain's boundaries because these roles interact in complex ways and can sometimes clash. The national legal structure should be clear and predictable. It should define the pertinent health and safety regulations as well as the labor and financial aspects that affect the activities of the private sector. And it should provide incentives to build active technology centers in developing nations that are linked to the local university system, thereby helping to create opportunities for the training and support of future scientists and engineers.

Every developing country should develop a clear, predictable legal framework with regard to the activities of the private sector. This framework should be compatible with the national S&T policy while providing incentives for real technology transfer. S&T-developing and S&T-lagging nations should consider regional and multilateral

cooperation and sharing of resources for implementing intellectual property protection, so that poor countries with limited technical resources do not have to duplicate effort, investment, and dedication of scarce talent.

12. FUNDING OF RESEARCH AND TRAINING EFFORTS

S&T should act as generators of social and economic progress; that give rise to a capability to innovate, which is essential to a country's competitive position. But many developing countries lack such capabilities therefore broad intellectual commitments of leaders in the developed and developing nations is required to develop S&T capacities of developing nations so that they may become serious participants in the world market. But to make these goals a reality, everyone should also commit themselves to the building of mechanisms for sufficient and sustainable funding.

The place of S&T capacity building should be secured among the priorities whereas the overall levels of all official development assistance should be increased as well. The prevailing programs for fellowships, training, and education can be expanded, so can be the programs of support for universities in developing nations. In addition, there are many innovative approaches being explored in the domain of international funding for development. Debt-swaps involving either foreign loan principal or interest, already used in terms of debt for nature swaps, could also be explored for S&T capacity building, as could some of the debt relief programs for the heavily indebted poorest countries, helping them to address the special recommendations for these S&T-lagging countries.

13. NATIONAL 'SECTORAL' FUNDING PROGRAMS FOR R&D

Sectoral funds i.e. redirected corporate taxes implement a national strategic policy to promote high-quality R&D in a country's industries. Such funds, as one now functioning in Brazil, require close interaction of the indigenous academic community, private sector, and government in creating it, setting its priorities, and managing it. Decisions are all jointly made on the selection of strategic sectors, their respective shares of the fund's resources, the blend of basic and applied research, the required overall budget, and sources of support.

Pakistan and India have reported successes with similar programs. As part of an agreement with the Government of Pakistan, the Pakistan Telecommunication Company Limited (PTCL), one of the country's largest commercial enterprises, devotes at least one percent of its annual gross revenue to S&T capacity building in Pakistan. Since the primary aim of this fund is to achieve self-reliance and enhance the quality of life in Pakistan, funding is made available for technological and scientific R&D projects in selected fields that are relevant to the country. In addition to R&D, funds go to training and education programs. Proposals are evaluated by a committee of leading Pakistani scientists who rely on the time-tested mechanism of peer review for deciding which projects should receive these funds. Priority is generally given to

scientific and engineering institutions with proven track records.

14. CONCLUSIONS

It is a known fact that indigenous S&T capacity is necessary for a country's development towards a knowledge-based economy and the main players involved in it are:

- Countries lagging behind in S&T
- Countries proficient in S&T
- United Nation's Agencies
- Inter-governmental organizations
- R&D institutes
- Educational and training institutes
- National academies of science, engineering and medicine
- Nongovernmental organizations
- National, regional, and International S&T organizations
- Media
- Local, national, and international private sectors (for-profit entities)
- Foundations

It is necessary that each of these players act independently as well as in collaboration with each other to achieve the desirable synergistic and sustainable results. Current conditions of any developing country will not necessarily remain the same forever. It is in their hands to improve the present and to create a better future for humanity. They have to work in such a way that S&T is utilized to fulfill their needs rather than adding to the luxury of a few. Therefore, it is absolutely necessary for a developing nation to strengthen their S&T capacity in this rapidly changing world. Foundations should be laid for a better tomorrow when the benefits of S&T will reach the traditionally detached, include the excluded, serve the unserved, and give hope to every human being on our planet that he or she too, has a chance to live in dignity, comfort, health, and happiness.

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ROLE OF VIRTUAL AND REAL NETWORKING IN BUILDING GLOBAL KNOWLEDGE-BASED ECONOMY

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1. INTRODUCTION

The phenomenon of globalization poses many challenges and threats of isolation and marginalization, particularly to the developing countries, unless they undergo a fundamental transformation to knowledge based economies. However, globalization also provides increased opportunities and options for countries of the South to participate in international trade and to share knowledge for building capacities in science and technology. The acquisition of scientific knowledge and its application to country-specific needs; through a pool of trained manpower, is the key to socio-economic development. Although a considerable volume of knowledge is being generated by the developing countries through basic research at R & D institutions, suitable mechanisms do not exist for its commercial exploitation. Few of the technologies created in research laboratories are developed to the industrial scale for lack of appropriate knowledge of transforming science into technology. The South-South cooperation in technical and economic fields, which began in the 1970s, offered an opportunity to the developing countries to work together by sharing knowledge and experiences for achieving self-reliance. It has been found over the years that the maximum benefit of cooperation is derived when the developing countries collaborate in areas in which their level of development is comparable.

While opportunities may exist for acquiring sophisticated knowledge and modern technologies, these cannot be adapted and utilized effectively without the existence of a sound infrastructure and relevant human resources. Modern technologies, imported at high costs in the form of turn-key projects, without fully understanding the science behind them, will not lead to long-term and sustainable growth. This emphasizes the need for a strong R&D effort in basic sciences to build a platform for receiving more advanced knowledge through regional or inter-regional cooperation. Several models have been proposed for measuring the knowledge-assets of a nation, which provide indicators for evaluating its present level of development. Such an analysis of knowledge-assets may be undertaken by developing countries, by adopting a suitable model, before entering into an alliance for cooperation in science and technology. The South-South cooperation in many areas has progressed well over the years and there are many success stories, which provide the incentive to pursue such programs of mutual benefit with even greater vigor.

The value of North-South cooperation to the developing countries cannot be overemphasized and must continue at an accelerated pace by facilitating the transfer of technologies that are adaptable, using the existing infrastructure, and meet the specific needs of the countries. Industrialized countries should also continue to provide training opportunities to scientists, engineers and social scientists from the South for designing strategies for dealing with hunger, disease and population-explosion, which are the biggest challenges to the developing world.

Much of the knowledge in science and technology is created by the North and most of it appears in the open literature. This huge reservoir of knowledge is available to the developing countries, without making any investment, and can be accessed through the internet or by other modern means of retrieving information. Intelligent use of this knowledge could provide solutions to many of the problems faced by the developing countries and may also provide a useful basis for initiating some developmental projects. There is urgent need for establishing communication-networks dedicated to the transfer of knowledge from North to South and within the South-South countries.

Many lessons can also be learnt from the "high performers" within the developing countries, like China, Brazil, South Korea and India that have taken the lead in the developing world by building large capacities in science and technology, and by taking timely decisions in response to the developmental challenges of globalization.

2. HISTORY OF SOUTH-SOUTH COLLABORATION

The beginning of some kind of cooperation between a group of developing countries can be traced back to the Bandung Conference, which was held at Bandung, Indonesia, in 1955. The representatives of 29 African and Asian nations met to discuss strategies for promoting economic and cultural cooperation between them. A ten-point declaration was adopted unanimously, which recognized the need for developing countries to reduce their economic dependence on the industrialized countries by establishing mechanisms for providing technical assistance to each other, through the exchange of experts for initiating developmental projects. The meeting also resolved to share technological know-how through the establishment of regional training and research institutes. The conference led to the establishment of Non-Aligned Movement (NAM) in 1964 which was organized by developing nations from Asia, Africa and Latin America and also the Group of 77 (G77) in 1964 created through a "Joint Declaration of Seventy Seven Developing Countries" at the conclusion of the First United Nation Conference on Trade and Development (UNCTAD). This declaration reemphasized the need to promote economic and social development within the developing countries, both through indigenous efforts and through the support of developed countries. The activities of the Group increased manifold after the UNCTAD and, in 1967, it adopted the "Charter of Algiers" at its first Ministerial Meeting to draw the attention of the international community to the fact that the prevailing trends in international economic relations were damaging to the developing world and widening the gap between the developed and developing

countries. The conference urged the developed countries to encourage the transfer of technology to the developing world and sought their guidance in availing of the investment opportunities in the world market. It was also agreed that special measures should be taken to help the least developed among the developing countries.

Cooperative activities during the 1960s centered around economic integration, lowering the trade-barriers and some political issues, through a series of agreements, such as, The Central American Common Market (CACM), The Latin American Free Trade Agreement, The Caribbean Free Trade Association , The Andean Sub-regional Integration Agreement, The Association of South-East Asian Nations (ASEAN) and The Central African Custom and Economic Union (UDEAC), all basically aimed at expanding the market-size, generate state-economies to support an accelerated industrialized strategy, and lay a foundation for more systematic integration of production-structures across national boundaries (Benn 1996). However the progress on these issues remained below the expected levels, mainly resulting from the lack of suitable infrastructure and poor communication-links. The 1970s saw the emergence of a more focused view on the South-South cooperation, on both technical and economic issues, mainly supported by the activities of the G77 and NAM which led to the adoption of a resolution by the United Nations General Assembly on the "New International Economic Order" (NIEO). Based on the concerns of the developing countries regarding the economic disparity between the developing and developed countries, the United Nations Conference on Trade and Development (UNCTAD) resolved to maximize the trade, investment and development-opportunities of developing countries and to assist them in their effort to integrate into world-economy on an equitable basis. During the same years, the United Nations Fund for Science and Technology in development was also established (UNFST). On the recommendations of a working group set up by the United Nations General Assembly in 1972, a special unit within the UNDP was established in 1974 (SUTCDC) to enhance the technical cooperation among developing countries.

In 1978, delegations from 138 states met in Buenos Aires, Argentina, and adopted a plan of action for promoting and implementing technical cooperation among developing countries. It was given the name "Buenos Aires Plan of Action" (BPA). The plan provides comprehensive details and guidelines on major issues of developmental assistance and highlights the importance of national and collective efforts by the developing countries for achieving self-reliance. The conference urged all governments and the United Nations Development Systems to take effective measures for its implementation, so that the developing countries could share knowledge and experience from each other as well as the international community for mutual benefit. TCDC was not to be a substitute for technical cooperation with developed countries of the North, which must continue for enhancing the technological capabilities of the countries in the south. The developing countries were given the responsibility, in this plan, for organizing, managing and financing TCDC activities with the support of the United Nations. A number of recommendations were also made for promoting cooperation among developing countries, which needed to be taken up at national,

regional and sub-regional, interregional and global levels.

However, there were a few recommendations which emphasized the need for cooperation in science and technology. This also marks the period when developing countries had not fully realized the potential of scientific knowledge for socio-economic growth. Investment in the creation, development, and application of science and technology to meet the specific needs of the country, occupied a low priority on the agendas of most governments.

More importance was given to the cooperation between developing countries in science and technology in the Caracas Plan of Action(1981) adopted by Foreign Ministers of Group 77.The leaders renewed their commitment to intensify cooperation among developing countries in science and technology, including the transfer of technology, and to work towards the attainment of national and collective self-reliance. The meeting called for support of the international community for strengthening and expanding the human-resource base, to take advantage of new technologies for sustainable development. Six areas of cooperation on regional and sub-regional level were identified in the Bali Plan of Action, which included science and technology, proposing the development of supportive networks between research institutions, universities and centers of excellence, sharing experiences in building institutional capacities, maximizing the utilization of training facilities in countries of the south for development of human resources, by organizing workshops and training programs in specialized fields. It also recommended the establishment of regional and sub-regional centers for the transfer of technology, including biotechnology. The leaders of Group 77 and China met again in Doha in 2005, to adopt the Doha Plan of Action and committed themselves to ensure its implementation with particular emphasis on the effects of globalization and promotion of knowledge and technology, to meet the new challenges. Under the title of "Knowledge and Technology", the participants resolved to strengthen the South-South cooperation in the field of science and technology, and encourage exchanges of expertise and experiences among research institutions and universities, facilitate exchange of programs, students, academia, and researchers and create provisions for scholarships and grants. The South-South high level forum on science and technology would meet regularly to oversee the progress. It was also undertaken to pay special attention to the promotion of education and the use of Information and Communication Technology for development, and to encourage the sharing of ICT knowledge and infrastructure among the developing countries through the use of virtual/cyber means of intensifying education and technical exchange between developing countries

In the Havana Program of Action in 2000, there was an increased stress on building science and technology capacities in the developing world. Highest priority was given to the eradication of hunger, illiteracy, disease and poverty, by mobilizing and sharing the available resources and expertise as well as complimenting cooperative programs with donor countries. South-South cooperation was recognized as an essential mechanism for promoting sustainable economic growth and achieving self reliance.

Regional cooperation and integration was identified as the most meaningful approach for the South, to face challenges of globalization and to take full advantage of the opportunities that it offered. Harmonization and integration of regional and sub-regional economic and social policies was essential for sustainable socio-economic development of the member states. The leaders at the conference reaffirmed their commitment to promote science and technology by strengthening political will, increasing the allocation of recourses to that end, developing an institutional frame-work and promoting innovation through advanced quality education. Developed countries were urged to facilitate transfer of technology, easing costs and relaxing collateral conditions. Combined participation of all social sectors, including the governments, private sector, non-government organization, scientific community and science and technology institutions, was urged for supporting the developmental process. Information technology, which constitutes one of the pillars of the technological revolution and is a powerful tool for development, must be included in the economic and social development programs so as to enable the establishment of global knowledge-partnerships. It is also an effective instrument for achieving equality in the field of economic growth and development, and for narrowing the gap between the developed and the developing countries, as well as facilitating access to knowledge and education at all levels of society.

It was also recognized that the rapidly advancing scientific and technological developments in the areas of microelectronics and biotechnology have contributed to the economic and social development and have influenced all areas of human endeavor. Since the ultimate aim of the governments should be to raise the standard of living of its people, it must invent, innovate, generate, acquire, absorb and use knowledge in any manner possible. Developing countries lag far behind in generating knowledge and in its application to new areas of industry, which provide increasing returns and rapid generation of wealth. Advances in technology can have an adverse effect on the environment and it is only through our knowledge of science and technology that the Earth's resources can be properly utilized and shared among its inhabitants without destroying our echo-system. Scientific knowledge is, therefore, emerging as a major source of power and influence on our lives and as a key factor in determining the sustainability of our planet and future prospects of mankind. Science and technology can also enable countries to overcome the barriers to their development, such as lack of suitable infrastructure, high costs of acquiring knowledge and technology, and small size of economies. These challenges emphasize the need to formulate appropriate strategies designed to promote cooperation in science and technology both regionally and internationally.

In view of the above-mentioned reasons for the urgency of cooperation between developing countries, a set of measures taken with full commitment and strong will of respective governments, include: strengthening of education infrastructure so that education can be imparted to all citizens, especially the females, removing impediments to the spread of knowledge, allocation of adequate resources for acquisition and generation of scientific knowledge, networking of research

institutions of science and technology, promoting closer links between universities, research institutes, industry and scientists, and involving people, governments, private and public-sector, civil society and scientists of the South based in the North. Countries in the South should exchange experiences and cooperate with others among the developing countries that have a competitive advantage in areas such as biotechnology, communication, production technologies and education systems.

3. INITIATING VIABLE SOUTH-SOUTH COLLABORATION

The countries in the South that are lacking in basic science and technology and Research and Development infrastructure needed to join forces primarily with one another and try to help each other. This is most practicable, as these countries can readily understand each other's difficulties and constraints.

Interestingly enough, the continents considered most backward in science and technology, and apparently lagging behind on the path to knowledge-economy, are the ones that were most advanced a thousand years ago. These are Asia and Africa. It might sound surprising, but the Muslims were the ones to initiate the thinking that led to modern science and technology. The two beacons of creativity and tolerance were located in Cordoba and Baghdad a thousand years ago.

Important changes over the past decade have given rise to the term "knowledge-revolution." The knowledge-revolution results principally from an intensification of the globalization process, the spread of ICT, more generalized automation and computerization of productive activities, as well as the increasingly tight links between science and innovation, and the development of new fields such as biotechnology. These changes are dramatically altering business-climates and the conditions of economic growth and competitiveness, worldwide. The economy that is taking shape is captured by the expression "knowledge-based economy" or "knowledge-economy." In such an economy, knowledge enriches all sectors and agents. It is a source of new industries and of renewal of established ones and is a key factor in competitiveness and social welfare.

At the same time, there is growing awareness worldwide, and now in the developing countries also, that the knowledge revolution offers new opportunities for growth resulting from the availability, of information and communication-technologies, as well as from the advent of a new forms of global economic development rooted in the concept of the knowledge-economy, which is based on the creation, acquisition, distribution, and use of knowledge.

For the greater part of the last millennium, the countries of the Middle East and North African (MENA) region were socially, economically, and technologically very advanced. Beyond their differences, they shared openness to knowledge and to other cultures. They represented the predominant civilization from the 8th to the 13th century and remained powerful until the 18th century.

These countries made innumerable contributions in mathematics, astronomy, medicine, architecture, and philosophy, so that the Islamic world was the main "global" provider of knowledge. It reactivated and added considerable to the discoveries of Greece and Rome, India, and China. The hunger for knowledge does not, by itself, account for the golden age of Islam, but it was a major driving force. Progress on the intellectual front was paralleled by the development of an economy based on a monetary market and commerce, along with technological advances, such as better and faster ships to service the merchant fleets.

The region declined because it was unable to find its place in an economy of iron, coal, and steam, an inability largely shared by all Mediterranean countries. Scientific thought and the principles of the modern scientific method—based on the questioning of dogma and on systematic experimental research—shifted to northern Europe. This is likely one reason why the MENA region, and the Mediterranean region more generally, dropped behind. It suffered the same fate as other regions bypassed by the earlier industrial revolution and suffered a serious setback lasting over two centuries.

The Baghdad "House of Wisdom" founded by Al-Ma'mun, the second son of the Abassid Caliph Harun al-Rashid (813–833), is a striking example of a flourishing knowledge-civilization. This is where Greek manuscripts were collected and translated and where scholars were welcomed, where the scientist and philosopher Al-Kindi discovered links between Platonic philosophy and Islamic thought, where Al-Khawarizmi conducted research on astronomy and mathematics (astronomical tables, an improvement on the Greek astrolabe), where Al-Battani worked on his book of astronomical tables (his contributions were such that the giants of early modern astronomy—Copernicus, Kepler, Galileo—referred to them in their work). In the field of pure mathematics, Arab contributions to algebra and trigonometry were fundamental: Al-Battani founded trigonometry (the sine and cosine functions), and algebra was established as an autonomous discipline by Al-Khawarizmi and geometric algebra by Al-Tûsï. Many stories have been told about the works of Al-Kindi, the first great philosopher of Islam, or about the genius of Abu Ali Ibn Sina (Avicenna), the medical doctor and thinker who, together with Al-Farabi (of Turkestan) and Ibn Rushd (Averroes of Cordoba) created the chain of Muslims who took Greek philosophy and ancient wisdom as their starting point and made their contributions to modern philosophical thought.

Cooperation among MENA countries is crucial for activating change and progress. Given the region's extensive linguistic homogeneity, trade and commercial exchanges are limited but can certainly be increased. Similarly, cooperation can be developed in science, education, and culture, using new technological opportunities and approaches such as open and virtual universities. Joint investment in (broadband) telecommunications would also facilitate integration. International organizations, including the World Bank, can play a crucial role in accomplishing these developments.

Although there has been an increasing interest in the south-south cooperation, progress over the years has not been commensurate with the comprehensive nature of the commitment embodied in the various declarations and programs of action. The lack of follow up and implementation mechanisms, has failed to bring out the full potential of South-South cooperation. The biggest challenge to the developing countries is from hunger, disease and overpopulation. Finding solutions to these problems will not be on the priority agenda of the countries of the North. The remedial steps have to be taken by the affected countries, either through their own programs of action based on indigenous knowledge, or by sharing experiences of other countries in the region that have been successful in dealing with these problems. Developing countries need to implement e-government to promote transparency and availability of information. It is high time that the developing countries of the Southern hemisphere of this planet awaken to the present-day realities and economic trends. Knowledge-economy is a fact that is here to stay and no nation shall thrive without acknowledging and accepting it. More important is the fact that the South-South collaboration is a must for the Southern region to prosper, on the path to global knowledge-economy. Be it Information and communication technologies, or biotechnology or the upcoming nanotechnology, networking of knowledge amongst developing countries for the sake of learning and promotion of science and technology will play a vital role in the emergence of a successful global knowledge-economy encompassing the sustainable economic activities of the developing countries.

4. SOME CONSTRAINTS TO SOUTH-SOUTH COLLABORATION

If true South- South help is to take place in a systematic and consistent manner, there is a vital need for it to be relevant and consistent for the recipient country's respective technological environment. Only then can the process of scientific learning be able to take root, and grow and thrive with time. Asking research centers in the more advanced developing countries to help those in poorer neighbors can only be justified on the basis of specific fields of cooperation, and not on proximity or membership of the same economic bloc.

Economists from certain developing countries, particularly Africa, have always been apprehensive of the South-South collaboration. Africa has long been the neglected continent and continues to be so. It is probably the most underdeveloped of regions on Earth. The developed countries have purposely neglected it over many centuries and only exploited it for their own colonization and mineral-extraction purposes. That is shameful. The world has been selfish with and cruel Africa. The skepticism is based partly on the view that South-South projects have tended in the past to deliver less than they have promised. The people of the poorest regions of the world, i.e., Africa continue to suffer. Another reason for the skepticism is the widening gap between regions of the world in scientific activity. One proposed response is the promotion of South-South Cooperation, for example, by inviting established research centers in the more advanced developing countries to help institutions in their poorer neighbors. This idea has been promoted since the 1970s and has become a cliché. It is a concept that has

had its day. Today's world is very different to that of the 1970s. Knowledge innovation is increasingly seen as the key to economic growth. And, in order to raise productivity, developing countries need to establish linkages with leading centers of innovation in the developing world and in the developed world. But they need to start with the developing world. These countries also need to take a fresh look at the role of the private sector and academia.

The global knowledge-terrain is marked by extreme disparities in the creation of knowledge. The developed world generates nearly 90 per cent of world scientific output. Similar patterns of knowledge-distribution are also reflected in the registration of patents and other forms of intellectual property-rights. Innovative activity is mostly concentrated in Western Europe, North America and Japan. The Scandinavian countries have advanced a lot in recent years and their hallmark continues to be the telecommunications sector. These disparities between the South and the North are partly a result of differences in the rate of investment in R&D and the overall support for inventive activities in these countries. According to UNESCO, global expenditure in R&D in 1994 was estimated at US$470 billion. Of this, North America and Western Europe accounted for 37.9 per cent and 28 per cent respectively. Japan and the newly-industrialized countries accounted for nearly 18.6 per cent. Africa's share stood at 0.5 per cent, and has been declining since then. These figures suggest that any strategy for developing science and technology in poor countries that does not seek to create alliances with centers of innovation in the developed world is likely to condemn itself to a marginal position. Discussions about South-South cooperation need to be viewed in light of this reality. Yet South-South cooperation is a must and a step towards a more comprehensive North-South knowledge collaboration. The Southern hemisphere has to be united for knowledge and be taking practical steps towards achieving a collaborative knowledge-economy. Only then and after that they may be able to negotiate their terms with the advanced North and will be in a position to comprehend the ways that North adopted to be what it is now. Somebody who has not passed the first grade can not be expected to sit and converse freely amongst tenth grade students.

Another feature of the current global science order is the growing role of the private sector in scientific research. An increasing number of countries are creating incentives and institutional arrangements that promote the transfer of research-activities from the public to the private sector. As a result, there is greater direct participation of the private sector in international negotiations. The South needs to make the best possible use of the forums available to it. This is necessary for it to make its voice heard. Organizations, such as TWAS (Third World Academy of Sciences), ISESCO (Islamic Educational, Scientific and Cultural Organization), TWNSO (Third World Network of Scientific Organizations), COMSTECH (OIC's Standing Committee on Scientific and Technological Cooperation) and South Centre have yet to play their full role. In fact, the list of South or Third World's scientific organizations does not end here.

In such a climate, reliance on public institutions as the main vehicles for technological

cooperation provides little prospect for success. Yet, in many developing countries, government and industry maintain mutual antagonism and suspicion - despite the fact that a country's competitive advantage depends on the degree to which the two cooperate in deploying their areas of comparative advantage. A developing country has to be united within itself – scientifically and bureaucratically – before uniting with other developing countries.

In this respect, a South-South Cooperation Model can only be justified on the basis of the characteristics of the specific fields in which countries are cooperating. It cannot be justified on the basis of proximity, or membership of the same economic bloc. Strategic alliances need to be forged between Southern organizations, irrespective of their geographical location. Geography can not be completely ignored though.

Biotechnology is one area that offers immense opportunities for such alliances. Biotechnology has the potential to contribute to new economic activities in the fields of agriculture, medicine and environmental improvement. It is unfortunate that very few developing countries are looking at biotechnology from such a point of view. Biotechnology, encompassing genetic engineering as well, has innumerable applications in the domains of agriculture, medicine, health and environment: these are the areas (poverty alleviation especially food shortage, healthcare, pollution control) where development is necessary in the developing countries. Developing countries need to exchange knowledge on Biotechnology theory and practice and update each other as much as viable in the particular relevant context. Governments of the countries of the South will still have an important role to play, but it will be different to the one they are used to. The state will need to catalyze the new South-South partnerships. And a key challenge to that end will be to integrate innovation into national development strategies, and recognize the importance of enterprise development as a basic requirement for technological innovation. The first step in moving in this direction is for the developing countries to take stock of their current position in light of major global economic trends and design strategies that reflect "reality". This should be their focus in technology policy research. Developing countries cannot afford a return to the perspectives of the 1970s.

5. SOUTH-SOUTH COLLABORATION IN KNOWLEDGE TRADE

Trade of goods, particularly capital goods, is an important source of knowledge transfer and acquisition. As part of their joint efforts to form a new knowledge trading bloc, Brazil, South Africa and India are increasing their collaboration in science and technology. The potential benefits are significant provided that other developing countries are also included.

It is a fact that knowledge is gained through exchange of expertise and merchandise between nations. Trade between countries is one way of learning one another's innovation skills and thus leading to a win-win situation. In trade, products are exchanged, ideas get exchanged also and this leads to mutual learning and addition in

knowledge. This addition in knowledge is critical for a developing country as this brings the country out of its self-contained isolation of limited knowledge and opens avenues of new knowledge accumulation. As new knowledge trickles in, and this is even in the form of a product manual, the curiosity of the receiving nation increases and also the interest to manufacture that product locally. This interest can be complemented by technological help from the providing country. Transfer of technology can take place when the two countries are ready for it at the administrative (government) level and also at the scientific (scientists, intelligentsia) levels. The private sector will have its role to accomplish as more and more institutions are being privatized in the developing countries. Such mutual trade becomes not only supply of products and services for the countries involved but also a channel for acquiring knowledge that shall initiate and drive new economic activities contributing significantly to national economy. Obviously knowledge-economy will be the result. The failure of certain international trade talks may represent a major setback for the efforts of developing countries to obtain better terms for their involvement in the international economy, but there is always a silver lining. This apparent failure has acted as a spur to greater collaboration between the Developing Countries themselves; pragmatic arguments in favor of South-South collaboration have now been reinforced by broader political concerns about the need to establish trading blocs amongst developing countries that can carry significant weight in future international trade negotiations also. Some of these negotiating blocs are essentially regional. And where these are in the process of being strengthened — as in Latin America, with the extension of the Mercosur Pact, or in sub-Saharan Africa, with the emergence of the New Partnerships for African Development (NEPAD) — scientific cooperation between neighboring, or near-neighboring, countries is clearly emerging as a key beneficiary. This, for example, was the clear signal to emerge from the meeting of African science ministers a few years ago, held under the auspices of NEPAD, which produced a coherent, if somewhat ambitious, plan for boosting science and technology efforts in the continent.

We must always remember that even in the South, one developing country differs from the other. This is due to the fact that some are really under-developed and some are developing and more in a position to help. There has been significant movement at another political level as well. This is the increasing alliance between the more advanced — and hence economically more powerful of the developing countries. Nations such as Brazil, India, South Africa and China are increasingly acknowledging that they share common social, economic and trade challenges. And, like other nations, they are also realizing that the chances of achieving these goals increase if they act together.

The signing of agreements between these countries to collaborate more closely in science and technology is a reflection of this trend. One such agreement was reached in September, 2003 when President Thabo Mbeki of South Africa visited India, accompanied by — among others — a group of senior science administrators from his country. Similarly when Brazilian President Luiz Inacio (Lula) da Silva visited South

Africa in November, 2003, one of the key outcomes of his visit was a new agreement between the two countries to collaborate in knowledge-sharing in the areas ranging from biotechnology to treatment of AIDS.

6. NEW INCENTIVES ABOUT TRADE AND KNOWLEDGE-EXCHANGE AGREEMENTS

There is nothing particularly new about scientific agreements between developing countries, which have been part of the staple diet of diplomacy for many years. Yet there is some hope of real progress. Early during his presidency, for example, South Africa's Nelson Mandela set up a Joint Commission with his Indian counterpart on a range of issues, including science and technology cooperation. China has for several years been closely involved in arranging bilateral deals, particularly covering scientific training. In the past, however, too many agreements have been little more than pieces of paper (a tragedy of the developing countries) — easy to sign, but lacking the political incentives to implement them in any effective way. That is now changing. A striking feature of the wave of agreements in recent years is that they are grounded in real social and economic needs. There is also recognition that these needs have a similar shape in different developing countries, and that one developing country can learn new knowledge about productivity from the experience of another.

These have given the new agreements both significance and urgency that their predecessors lacked. Consider the question of the complex relationship between indigenous knowledge and patent rights. Each of the countries mentioned in the last few paragraphs is rich in both biodiversity and local cultural traditions, making them prime targets for those seeking traditional knowledge that can be incorporated into, for example, new medicines. Each is now facing the task of devising methods to protect their traditional knowledge that are compatible with the intellectual property rules of the new international knowledge-economy. There is a strong incentive for sharing experiences and novel solutions. India has offered to do all this, for instance, with its promise to help South Africa set up an electronic database of traditional knowledge comparable to the one established in Delhi by the Centre for Scientific and Industrial Research (CSIR).

Another example is of genetically-modified crops. Many countries are facing the similar dilemma: how to square the disquiet about the potential environmental impacts of such crops with the strong social and economic forces that favor them. It is significant to mention that when the Indian science and technology minister Murli Manohar Joshi visited Brazil with a high level delegation in July 2001, considerable time was spent discussing this issue at the Agency for Agricultural Research in Brasilia.

7. A SOCIO-ECONOMIC AGENDA FOR THE 21ST CENTURY

It would be naive to pretend that South-South collaboration on such issues will ever be

a complete replacement for collaboration with the more scientifically advanced countries of the North. Avenues of support must remain open at the scientific level and the "meta-scientific" level — the area where science and politics overlap —since what happens in one part of the world increasingly effects the way that issues are both perceived and handled in another (ranging from the issue of human cloning, to the conditions required for membership of the World Trade Organization). Many of the challenges currently facing the South — from malaria to infant mortality — are of little interest to countries in the North. In such areas there is a need for developing countries to be self-sufficient. South-South collaboration has its crucial role here.

One danger to avoid, of course, is that such capacity building through collaboration becomes limited to the major developing nations. It is essential that they share their own knowledge and experience with the under-developed countries as well. There are some promising signs in this direction. At a meeting of TWAS in Beijing, a number of countries (including China, Brazil and Mexico) announced new research fellowship programs specifically targeted at young scientists from the least developed nations. TWAS itself has placed similar forms of mutual help high on its immediate priority list. Such efforts have the highly pragmatic outcome that they will help to identify and train talented individuals in countries whose scientific efforts are likely to be of benefit to the whole developing world. The more the larger developing countries can ensure that their efforts at collaboration — in science and technology — have a constructive economic agenda, the greater is likely to be their positive contribution to global development during the rest of the 21st century.

8. SOUTH-SOUTH COLLABORATION AGREED WITH RESOLVE TO PRESERVE AND INCREASE THE KNOWLEDGE-BASE OF THE DEVELOPING WORLD

The 119-member Non-Aligned Countries Movement (NAM), of which the 53 African nations are members, has agreed to promote South-South cooperation in the knowledge exchange of health, water research and renewable energy. The agreement was reached in Havana, Cuba, during the 14th NAM summit of heads of state from 11th to 16th September, 2006. In a declaration, the leaders called for improved water resource management and scientific understanding of the water cycle through cooperation in joint observation and research, and accelerated development and deployment of Renewable Energy Technologies.

The declaration also highlights the importance for promoting South-South cooperation in the fight against HIV/Aids, malaria, tuberculosis and other communicable diseases, including avian influenza. Furthermore, it urges the international community to address the negative impact of the migration of skilled personnel and highly educated people from developing countries (Developing World's Brain Drain).

Addressing the opening session of the NAM meeting, Carlos Lage Davila, vice

president of the Council of the State Republic of Cuba, said, "Walls are erected across borders and immigration police forces assembled, but not to prevent the entry of scientists, doctors, nurses, information experts and other highly qualified professionals and technicians into rich countries." This is a fact that has recently caught the attention of the developing world with its full significance. The developing countries need to keep their knowledgeable people from leaving while ensuring excellent opportunities for them in their indigenous environment to exercise their intellectual potential in a way to enhance their own learning while contributing positively to national economy. South-South cooperation will have to create innovative jobs for such skilled personnel through knowledge networking of Developing countries.

This declaration would help NAM countries to enhance partnerships that promote South-South cooperation for science and technology development. However, the suggested fields of cooperation need to be implemented by action plans. Action is a pre-requisite to any positive outcome in the form of social or economic growth. Science partnerships should focus on agricultural research in areas such as conservation, linking farmers to markets, improving biological pest control and improving crops for health. Capacity building, capacity utilization and capacity retention in developing countries is necessary to discourage the incessant migration to the developed countries.

9. SOUTH-SOUTH COLLABORATION IN KNOWLEDGE AND TECHNOLOGY TRANSFER

The expectations of a number of institutions in Australia, Belgium, Brazil, Egypt, India, Malaysia, Mexico, Netherlands, Philippines, the Republic of Korea and the United Kingdom, have become a real success. When these institutions were visited by a UNIDO team of experts, their managers expressed full support for a project concept of an international centre to be designed as a gatekeeper for developing countries in the field of advancements in manufacturing technologies. The Centre was expected to track the latest worldwide developments and bridge the gap between the emerging market demand and the existing technology base. The concept has become the self-enhancing project with impact. Its success lies in the integration of technology transfer with investment promotion, small and medium-size enterprise and private sector development, South-South cooperation and networking. Government organizations, private sector and banks have started joining their forces to put their financial resources under one umbrella.

A US$2.7 million project took off in October 1999 when UNIDO and the Government of India signed a trust fund agreement for UNIDO assistance in the pilot activity phase (1999-2001) for the International Centre for Advancement of Manufacturing Technology (ICAMT) in India. Under the agreement, signed on 29 September 1999, the Government of India, as the host country, provided US$1.3 million as well as premises for ICAMT in Bangalore and office accommodation in New Delhi. UNIDO allocated

US$100,000 for the immediate implementation. The ICAMT work program was formulated to boost the competitive level of manufacturers in Developing Countries and to assist these countries of the South in enhancing their technological performance in manufacturing, productivity, quality of goods and competitiveness through the transfer of advanced manufacturing technologies, promotion of South-South cooperation and building up partnerships for sustainable development.

The first event, International Entrepreneurial Meeting on Manufacturing Materials for Low-cost Housing, was held in Bangalore, December 1999. UNIDO, ICAMT and the Building Materials and Technology Promotion Council (BMTPC), invited more than 70 managers from R&D institutions, entrepreneurs and policy-makers from India and nine African countries. As a result, some 45 contracts for the purchase of equipment and 5 memoranda of understanding in the production of alternative materials for low-cost housing in Africa, were signed. African entrepreneurs and buyers expressed their interest in trading in Indian products, setting up commercial production units and obtaining licenses for fabrication of the machines developed and being manufactured in India. They were particularly interested in Indian machines for making simple building components, finished products and solar-energy appliances. Opportunities for partnership encouraged African delegates to lead the development and transfer of low-cost technologies in the region.

The Bangalore meeting, promoting South-South cooperation, confirmed the ICAMT's mission on Technology-Transfer from Asian countries to Africa, as African entrepreneurs considered these technologies most appropriate for being transferred and absorbed by small-scale industries in their countries.

ICAMT has actively publicized its activities. The Centre sponsored an Asia-Africa Technology Partnership Forum, which was held at the exposition venue of the Millennium Enterprise 2000 in New Delhi, March 2000 - the first exposition of small industries in India. An exhibition of products manufactured by Indian SMEs took place in South Africa in June 2000.

The Centre also initiated new projects. Under an agreement signed by UNIDO and the Indian Ministry of Urban Development and Poverty Alleviation in Vienna, June 2000, the Centre is to provide the Indian expertise and manufacturing technologies for low-cost housing for human settlements in the selected African countries (Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia and Zimbabwe). The project encourages and develops technical cooperation among the developing countries in the manufacture of cost-effective materials based on local resources. Signing the memorandum of understanding, both sides agreed on a pilot project (Investment and technology promotion and transfer for manufacturing composite materials for low-cost housing in Africa), estimated at US$250,000, with the amount of US$125,000 provided by the Indian Government under the trust fund agreement. A larger regional integrated program is under development.

In Tanzania, more than 200,000 African architects, engineers, building material manufacturers, businessmen and government officials, among them two heads of state, visited the India-UNIDO Exhibition in Tanzania, July 2000. The Indian Building Material and Technology Promotion Council exhibited technologies and machinery used for manufacturing of composite materials for low cost housing. Parallel to the exhibition, an International Seminar on Building Materials and Manufacturing Technology for Low-Cost Housing in Africa attracted some 217 African participants.

During its existence, ICAMT has also organized four training courses in: transforming business with the Entrepreneurs Resource Planning (ERP), CNC maintenance, rapid prototyping and patents with the participation of 160 entrepreneurs and researchers.

9.1 South-South Collaboration in Agriculture Knowledge-Exchange: Over the years, as part of their effort to strengthen agricultural research in the developing countries, the Centers of the CGIAR (Consultative Group on International Agriculture Research) have come to work with tens of thousands of scientists from developing-countries (Asia, Africa and Latin America), who bring their skills to international agricultural research and return to their own national systems with those skills enhanced. This two-way knowledge-enhancing process is the cornerstone on which ISNAR (International Service for National Agricultural Research) founded its Global Associates program, initiated in 1998. The network of Global Associates, expanding to a total of 17 in 2001, has continued to be a fine example of innovative thinking and knowledge sharing. Agriculture, still at the heart of the economies of the developing countries of Africa and Asia, needs to be enriched through exchange of subject expertise amongst the scientists of the respective countries.

ISNAR's Global Associates is composed of outstanding, experienced scientists who have remained in the employment of their own national institutions but keep allocating a portion of their time to work with ISNAR on projects in other organizations and countries. They have been able to provide cost-effective services to national agricultural research institutions that seek professional advice in a range of economic management skills. Countries involved included Kenya, Zambia, Philippines, Peru, Nicaragua, Chile and China. Especially well attuned to the challenges faced by Developing Countries and often closer in language and culture, the Global Associates are able to respond sympathetically to the needs of national agricultural research institutions. Through the program they gain wider knowledge and experience, which, in turn, strengthens their own organizations and economies.

The Global Associates network is an excellent example of South-South collaboration facilitated by an international organization, and it clearly demonstrates that recruiting scientists from the South to work on the developing region's projects makes sense. Such work is complemented by ISNAR's effort to strengthen its ability to pursue new and more entrepreneurial approaches to

support agricultural research and knowledge innovation for the improvement of socio-economic conditions of the developing nations.

9.2 A knowledge delivery network for Brain-Gain in Developing Countries: ISNAR Global Associates is also building a network of outstanding professionals, mostly in developing regions, to work for ISNAR on a part-time, as-needed basis. These part-time staff, also known as "ISNAR Associates", help expand ISNAR's global reach in a cost-effective manner. By contributing to capacity building in many countries, ISNAR Associates gain more expertise and experience, which they can use to strengthen their own organizations. The network of ISNAR Global Associates is helping agricultural research institutions in developing countries to better meet the challenges of the 21st century.

The 21st Century presents developing countries with a number of far-reaching economic concerns. Globalization is challenging national economies to adjust to new patterns of trade, prices, and production. The Internet is changing the way of communication at an amazing pace. Agriculture is also expected to be wrenched by a transformation that will be driven not by trade or communications technology only, but by genetic engineering also.

Much attention to-date has been focused on the controversy surrounding genetically modified foods. Less attention has been given to the even more profound change that lies ahead: the ability to manipulate genetic codes of living beings will set off an unprecedented convergence of farmers, scientists, doctors, drug makers, computer companies, communication companies, and enterprises concerned with the life sciences. For the economies of the countries of the South to succeed in this new socio-scientific environment, totally new knowledge, skills, and alliances will be required.

From the last millennium we inherited the global goal of poverty alleviation. Currently there are nearly 800 million undernourished people. About 1.2 billion people live in absolute poverty on less than US$1 per day, and this number rises to 2.8 billion if the poverty line is shifted to just $2 per day. Our challenge is to help ensure that the economic changes that will be sweeping through the agricultural sector will improve the well-being of everybody, including all the poor and the future generations.

9.3 Trade and Economic Integration in the Developing MENA Region: The Muslim world played a central role in the development of the Silk Road, which might be viewed as the first instance of globalization. The inclination to trade remains very perceptible domestically, but MENA countries have unfortunately, been left behind by the recent globalization process because of their poor investment climate.

The MENA region is the region that is least integrated in world trade flows. However, tariff and non-tariff barriers have been lowered in recent years, and a number of agreements with the European Union should also be helpful in this

regard. Trade liberalization is not enough, however. Bureaucracy and corruption must be reduced, and transport infrastructure, telecommunications, and services, notably financial services, must be modernized. These developing countries have little incentive to engage in intra-regional trade, given that a number of them are largely oil producers. There are however opportunities for trade integration when economic structures are complementary. The gradual shift to more diversified bases of production, with finer product differentiation and design and other improvements from a knowledge-economy perspective should encourage integration throughout the region.

9.4 Trade Integration and Comparative Advantages between Lebanon and Syria: Syria is endowed with natural resources, land, water, minerals and a growing labor force. It has a comparative advantage in agriculture and industry, including the potential for developing agribusiness. It has invested in infrastructure but requires financial resources and substantial investments.

Lebanon has a comparative advantage in banking and financial services and can provide the financial resources Syria requires. Many Lebanese banks have been set up in Syria. This opening up to foreign financial services, international banking, and financial markets through the Lebanese banking system is creating healthy competition, helping introduce the required innovations in payment systems, banking, and financial services, and ultimately creating closer economic integration between the two countries. Increased specialization and the signing of an association agreement with the EU (European Union) would also lead to better integration into EU supply chains.

9.5 Poorly Developed Innovation Systems in the Developing Countries: Promoting a technologically creative and innovative economy presents a considerable challenge the countries of the South. One can hardly argue that these countries have, at present, true innovation systems founded on extensive interaction among research, production, and training. Some elements are there, fragmented policies have been set into place, but clear structures, with competitive assets, are lacking.

Egypt has emphasized higher education and produces highly qualified and specialized personnel. However, the innovation system remains fragmented and very much centered on these institutions. A second group of countries, including Morocco, Tunisia, Jordan, and Kuwait, has adopted more open and demand-oriented processes and has attracted foreign establishments and developed subcontracting activities. They have developed science and technology in specialized areas but have not made this part of a comprehensive development policy. The industrial base of Syria and Yemen, is insufficient to develop an innovation system. The Kuwait Institute for Scientific Research (KISR) and the Egyptian Academy of Scientific Research and Technology (ASRT) are among the most successful public research institutions in the MENA region.

9.6 Tapping into Foreign Technology and Knowledge: Foreign direct investment is the primary means of taking advantage of foreign technology. Experience shows, however, that the firms that benefit most from FDI are those that supply parts and components to foreign subsidiaries involved in the assembly and production of finished goods. This is because these suppliers receive strict guidelines regarding quality, standards, and delivery conditions. They also benefit from sophisticated equipment and machinery. Another benefit of FDI is the impact on the skills of employees of foreign subsidiaries and of their suppliers. However, as noted above, most developing countries still receive very little FDI. This again shows the importance of a systemic approach to improving the overall investment climate. Appropriate regulations and R&D structures are needed so that countries can benefit from technology transfer from foreign firms and increase local innovative capabilities.

A second way to acquire the necessary knowledge and technology is to seek them out, particularly in advanced countries, and make appropriate arrangements for international cooperation, joint ventures, licensing, and so on. Countries such as Korea and Chile have systematically developed networks and organizations for this purpose. Some Middle East countries are also occasionally involved in such practices, notably in the oil sector. Agriculture and water management present similar opportunities. Efficient public research institutions seem to be an appropriate vehicle for tapping into global knowledge , provided that there are then adequate mechanisms for transfer to the private sector.

Human resources constitute the third, and probably most efficient, way to tap into foreign knowledge. Dubai, for example, which has an aggressive development strategy, has tried to attract a highly trained and competent foreign workforce to help to develop new fields such as software or the media. There is also an important Diaspora of highly qualified expatriates who are currently employed by firms, universities, and laboratories in advanced countries. According to some estimates, there are more than 1 million highly qualified Arab expatriates in OECD countries (UNDP, 2002, p. 71). Developing countries, following the example of countries such as China, may take measures to attract them home. Experience shows, however, that as long as the general environment for working, innovating, and conducting business is problematic, and more generally until they can enjoy a standard of living comparable to that in the advanced economies, expatriates do not return.

It would however be useful to consider the establishment of strong innovation promotion agencies with adequate resources, an effective staff, and sufficient authority to intervene wherever and whenever necessary in the innovation process. OECD countries offer various models, which may help developing country policymakers meet various objectives and needs. For instance, France's ANVAR has efficiently supported the creation and growth of innovative firms (notably on a regional basis). Finland's TEKES has very effectively promoted

research collaboration and innovative programs involving university and public laboratories on the one hand and the business sector on the other. The Fundación Chile has been a remarkable instrument for the growth of competitive traditional sectors.

9.7 Telecommunications and Related Policies for the Countries of South: The telecommunications infrastructure plays an essential role in the knowledge-based society. It is also indispensable in the struggle against the digital divide and for breaking down the isolation of rural areas. Furthermore, the telecommunications infrastructure is essential in the developing countries that are experiencing conflict, as it can replace transport.

10. SELECTED SUCCESSFUL EXPERIENCES OF EVOLVING KNOWLEDGE-BASED ECONOMIES

10.1 Malaysia

After decades of laissez-faire economic policies and export-driven growth, Malaysia designed a development strategy based on economic and rural development and socioe-conomic equity that has prevailed for the last 30 years. It has achieved average growth of 7 percent over the 1960–2000 period. It successfully migrated from the agricultural age to the information age in one generation (1970–2000). Absolute poverty has decreased from 49.3 percent to 7.3 percent in 30 years.

From 1971 to 1990 Malaysia implemented a new economic policy having growth with equity as its central concept. From 1991 to 2000, it had a balanced national development policy. From 2001 to 2010, it aims to build a resilient and competitive knowledge economy. In the late 1990s, when it was severely affected by the Asian financial crisis, Malaysia decided to leap into the knowledge age. It developed an ambitious ICT program that was designed to drive growth and bridge the digital gap. The program included the building of a "Multimedia Super Corridor," the establishment of many ICT centers throughout the country (40 information technology community centers are accessible to 1.2 million people), and investments in education and human resources. The choice of the knowledge economy was the result of both a vision and a crisis which was perceived as an opportunity for change.

10.2 S. Korea

S. Korea offers another example of a knowledge-based development strategy to overcome problems experienced during the 1998 Asian financial and foreign exchange crisis. In the wake of the crisis, Korea became particularly receptive to this new development concept, and the Korean president launched a national knowledge-based strategy. In April 2000, led by the Ministry of Finance, and supported by a World Bank-OECD report, the strategy evolved into a three year action plan for five main areas: information infrastructure, human resources, knowledge based industry, science and

technology, and elimination of the digital divide. To implement the action plan, five working groups were formed involving 19 ministries and 17 research institutes. New activities related to high technology and related services spread quickly and broadly, reducing the unemployment rate from 7 percent in 1998 to less than 4 percent in 2002. The contribution of the information technology (IT) industry to GDP is estimated to have increased from less than 15 percent in 1996 to more than 50 percent in 2000. Foreign reserves have been reconstituted to record levels (more than US$100 billion in 2001 from less than US$10 billion in 1997).

10.3 Dubai: An Emirate Moving toward the Knowledge Economy

Dubai shows that it is possible to formulate a vision to be reached in several stages. Its transition from an economy dependent on natural resources to a full-fledged knowledge-economy originated with a vision shaped and developed by Dubai's chief executive officer. As in most Middle Eastern economies, a considerable decline in income from energy exports, rapid population increase (5.8 percent a year), and limited FDI were impeding Dubai's economic growth and development in 1995. Market objectives involved transforming Dubai into a "node in global networks," a world hub to act as a regional leader and a bridge between Europe and Asia. Dubai's knowledge economy strategy encompassed three phases. Horizon-1 focused on Dubai's assets in trade, logistics, transportation, and tourism to capitalize on "what Dubai does best." This enabled Dubai to diversify production and to propel itself toward a knowledge economy. Horizon 2 revolved around the application of core competencies to new areas such as technology, financial services, media, telecommunications, and IT and was structured around technology, ecommerce, and a media free zone (TECOM) consisting of three separate business entities: Dubai Internet City, Media City, and the Knowledge Village. These entities were crucial to the success of Dubai's strategy since they were concrete knowledge economy applications in the form of visible projects. Finally, Horizon 3 built upon the revenues leveraged in Horizon 1 and 2, which were invested to project and develop future competencies.

11. FORMULATING LINKAGES WITH THE DEVELOPED WESTERN-WORLD

11.1 Constraints of Development in the Underdeveloped World and the Role of North-South Knowledge-Collaboration: The underdeveloped part of the world is characterized by imperfections in planning, administration and management of its natural resources. All this has led to weak economies in the under-developed countries over the past decades and centuries. It is also a region that has failed to arrive at a form of governance, where plurality prevails in various forms. Therefore, the consequences of this state of affairs characterize the underdeveloped part of the world as carrying the largest burden of misery, poverty and destitution. Kindly speaking the "underdeveloped" is called "developing".

The countries of the developing world, to the frustration of many, have become associated with perpetual receipt of foreign relief aid, and are driven by frequent

ethnic and religious conflicts that have necessitated ill-conceived peace-keeping missions. Such aid and relief does not really work in the long run as these developing countries just "eat to live the day", and do not learn to do things themselves. As Mao Tse Tung once said that it is better to teach someone to "fish for himself" rather than give him a fish every day.

To a successful individual from one of the nations of the developing world, living in the affluent west (exiled or by choice), there is nothing more humiliating than to be approached by a condescending colleague to be told that "…how lucky he/she is to have avoided the starvation back home by immigrating...". And even worse is to hear cynical remarks directed at a bona fide scientist of a developing country origin that "… why don't you go home and grow better crops and feed your people if you are this smart? …" . Such anecdotes are not isolated incidents and convey a message of far reaching implications about what needs to be done to change the wrong image of the developing countries. The developing countries have to be put on a track of self-development that ensures that they have a quest for knowledge that can not be quenched easily and will always drive them forward on the path to learn. The "Developed" world, may it be in West or North of planet Earth, has to play the role of the elder brother who is always there to guide and push in the correct direction. "North-South" collaboration for the sake of uplift of the economy of the developing region of the world is one thing that shall help not only the south in the long run but also the North. Similarly if the north does not show its genuine concern now and help the South enter the global knowledge economy, in the long run, the North will definitely suffer along with the South may that be in the form of crime or terrorism.

Internally, the majority of the developing countries have serious problems, which are caused by an undemocratic and dictatorial state apparatus. These states have been promoting uneven development among the different regions or peoples within the country. In most developing countries, the prevailing unstable conditions have been driving the educated few of the South to greener pastures in the North. Education and scientific research that are known to serve as key stimulants for Development have been dwarfed in the South. "Brain Drain" for the South and the resulting "Brain Gain" for the North are not going to be too good for either side in the long run.

Since their adoption at the UN Millennium Summit in 2000, the Millennium Development Goals provide a road-map to the developed and developing countries for improving the general well being of their people. Meeting the challenges faced by most countries, including economic productivity, education, health, drinking water, sanitation and environment, will require a major transformation of national policies to the knowledge-based approach for economic growth through the use of new and established scientific and technological innovations. Countries must recognize the need to build capacities in science and technology to reap the benefits of rapidly growing knowledge.

Technological innovation is pivotal to the long term development and must lie at the center of all policy frameworks. Sustainable development requires national initiatives and international partnerships that allow mutual learning.

The example of some developing countries in Asia Pacific region that succeeded in alleviating poverty and grew their economies through the application of scientific and technological knowledge provides useful guidelines for other developing countries to follow the same course. One of the major hurdles in the development processes of the developing world is the lack of adequate infrastructure, which is essential for the effective application of science, technology and innovation for development. The developing countries must recognize the areas of policy actions that would suit their national needs, laying special emphasis on the development of infrastructure and infrastructure-services that would be necessary for implementing those policies. Investment in science and technology to build capacities is one of the most important factors in determining the rate of economic transformation. Attention must also be paid to streamline the education system from primary to the university-level and economic opportunities should be created so that the graduates can apply their acquired capabilities for addressing local and national needs that require advanced knowledge.

The universities must contribute more effectively to the economic developmental processes. Apart from conducting research in areas relevant to the needs of the country, universities should be encouraged to initiate entrepreneurial activities that would improve regional and national economic and social performance. The results of R&D could be utilized for creating spin-off units, development of capital-formation projects like technology parks, and business-incubation facilities. Indigenous capabilities must be commercialized to generate wealth. Universities may also provide entrepreneurial training for enabling scientists and engineers to take research from laboratories to the industry. New institutions devoted to the promotion of business incubation and community development need to be established and strong links between universities, academic societies, industry and government are necessary for acquiring and applying new knowledge for a healthy economic change. Although new knowledge is being created in the developing world, either through indigenous efforts or in collaboration with international partners, the conversion of this knowledge to revenue-generating projects is one of the biggest challenges facing the developing countries.

To be able to participate effectively in the international trade developing countries need to adhere to the high standards of manufacturing and exercise strict control of product quality. This would require setting up an independent authority for overseeing the quality control of manufactured goods and certify that required standards have been met. This has become more important since the developed countries are now outsourcing to the developing countries the manufacture of a variety of goods which they are able to produce in accordance with the given standards. Finally, human resource development has a direct bearing on the

scientific and technological development which is the engine of economic growth. No amount of investment is excessive in preparing a pool of skilled and highly trained manpower. The north-south cooperation programs can be invaluable in achieving this objective in addition to the role that national universities can play.

11.2Education, Science and Technology for Economic Development – Knowledge-Economy: Examples from recent decades exist from ex-Yugoslavia and elsewhere that exhibit that at times rapid rise of science and technology has done little for the improvement of man's moral behavior. Yet the path of education, science and technology to the West's scientific and economic dominance over the rest of the world can be traced. This is appreciated better when we draw our attention to the fact that about 500 years ago, Europe was desperately poor in comparison with the great civilizations of the East and the South. This has been discussed earlier in this chapter in the part of South-South collaboration. However, the foundation of Europe's future wealth had been laid by then - the foundation has been a single philosophical idea which today is called "science", and in the olden days was known as "natural philosophy". Natural philosophy's immense strength lay in its power of prediction while making use of scientific methods and inquiry. Therefore, it is confirmed that the essential ingredient of Western civilization and prosperity is the use of science and technology.

As Kurt Mendelssohn (1976) observes, "In addition to greed for riches and domination, the West became possessed suddenly of a strange spirit of adventure, of an insatiable intellectual curiosity that have driven them for the past 500 years". Such a spirit, unfortunately, has been uncharacteristic of the South for the last 500 years. However, after centuries of fatalistic and ignorant attitudes that were anathema to scientific thinking and practice, the South has recently awakened to the realization that education, science and technology build and determine the tempo of socio-economic change. As a result of this new awakening, what is now witnessed is an attempt by the South to quickly absorb, in a somewhat undigested form, the so-called "blessings of Western science and technology", from electronics to automatic weapons. The most bewildering aspect of this erratic access to Western technological products is that the developing world has, by and large, become the dumping ground for lethal ammunition, used as an instrument of many civil wars. For example, the Horn of Africa, a focal point of instability and civil strife, is a good example of import of western technologies for destruction of all past achievements and for making future developments impossible. The facts can not be ignored. For the peoples of the South to be able to think and function scientifically, "Basic" or "Primary" Education is an absolute necessity. On the other hand, in countries of the South where an illiteracy rate of more than 75 percent prevails, dreaming of a Modern Democratic Culture of managing social affairs and ultimately thinking of a democratic system of Governance is grossly unrealistic. As Alfred North Whitenhead correctly summed up: "In the conditions of modern life, the rule is absolute, that is, the race which does not value trained intelligence is doomed. Today we maintain ourselves, tomorrow science will have

moved over one more step and there will be no appeal from the judgment which will be pronounced on the uneducated."
Raising the literacy rate of the population by paying adequate attention to education of women is also a necessary springboard for the introduction and implementation of developmental programs, leading to economic progress in the developing countries. Furthermore, technological literacy is unimaginable under conditions resulting from a low standard of education. Therefore, a gender conscious investment in general education of the population of the developing nations is a priority for development.

Last but not least, population planning in countries of the South aimed at maintaining harmony between economic growth, carrying capacity of the land, and conservation of natural resources of the region, can only be attempted when the educational standard of the population has passed the critical threshold.

The critical ingredients for the Sustainable Development of a country are universal in character. These constitute an educated manpower, natural resources and a democratic system of government. We must recognize the void apparent in "forced development" that could be achieved through policies of command economy, which many dictatorial governments have registered. Global reality reveals that such developments are only ephemeral and fraught with social upheavals that have been reversing the "forced achievements". Thus, such developments are not sustainable.

For a sustainable development, in addition to the peaceful and democratic atmosphere needed, a country is required to invest in the systematic development of its manpower at Higher Education levels. Likewise, a closer look at the histories of development of the affluent societies of today depicts manpower development as a prerequisite for such achievement. Human Resource Development is inevitable. A rich resource base of a country alone is of little value for the well-being of the social economy if an appropriately trained manpower that can exploit it and the necessary political environment to allow maximum expression of the competent knowledge skills is non-existent.

Another component necessary for growth and development that can only be undertaken by an appropriately trained manpower is research. Research is the sole exercise for generating knowledge about natural phenomena in general and can be geared to addressing specific local problems. The two types are called "basic" and "applied" research respectively. We are in a period in world history where both knowledge acquisition and generation have been globalized. Therefore, it is necessary that the educational and research efforts of the South be adequately linked with that of the North. Hence, it is within this global context of North-South knowledge collaboration that we can think of the sustainable development of the South.

11.3Latecomers' Advantage in Science and Technology: Not to be easily swayed by the prevalent notion that the generation and use of technology in developing countries is not economically sound, if not impossible, the experiences of some countries that demonstrated a fast track of development are illustrative. For example, Japan's rapid development was triggered by the realization that good education is a prerequisite for a country's technological advancement and hence, economic progress. As Toshio Shishido (1993) (Vice President of The International University of Japan) remarked: "As a latecomer in industrialization, Japan had the particular advantage of being able to choose well-established technologies from already developed countries and save the costs of trial and error. However, to do this, Japan had to make full use of its development planning abilities and educational resources."

Likewise, South Korea's advancement in economic and industrial development began with the national conviction that science and technology are the key elements for growth and development. This was followed by a step by step approach to popularize and implement appropriate technologies.

Therefore, to enhance economic development in the developing countries, a suitable environment for the popularization of science and technology must be created. It is necessary to cultivate a rational and scientific way of thinking among the population and to discard passive attitudes and practices. To do this, the population must comprehend the importance of science and technology in economic development and must develop the habit of applying elementary technical knowledge to everyday life.

The necessity of international cooperation in science and technology, for the benefit of both developed and developing countries, is clear since the development of science and technology is not possible in closed or isolated societies. Thus globalization of the problems and the way solutions to the problems are sought makes the rational basis for North-South cooperation. This being the case, it is not only the North's philanthropic disposition that is responsible for the development cooperation programs that exist with the South. The driving force is the need for creating a better global home for all mankind and its future generations.

11.4Role of Academia in Economic Development: Universities and colleges are higher education institutions where globally existing knowledge is acquired and new knowledge is also generated through research. However, the universities and colleges of the South are either too young and hence lack the necessary experience, and/or are poorly organized and equipped in terms of manpower and resources to serve the purposes of knowledge acquisition and generation. The programs of North-South collaboration between South's universities and research institutions of developed countries of the north are an innovative approach that attempt to address the problem of development in the underdeveloped countries. By assisting the South with higher education and research, the North has chosen the most

pertinent point of entry.

The limited capacity and low research competence of the universities in the developing countries do not allow them to effectively discharge the responsibilities they were created to serve. Therefore, most universities and colleges of the developing countries would require support of one kind or another, to improve the respective country's ability to engage in development activities. The cooperation scheme of the North's universities and research institutions with those of developing countries is an innovative approach aimed at enhancing quality education and research competence in the South.

North has been helping the South. Norway is a good example of it. It must be noted that currently (2007), Norway is amongst the most advanced and developed countries. Its HDI (Human Development Index) is the best in the world and on an incline. The program of North-South collaboration between universities and research institutions (NUFU) of the Norwegian government has been supporting research institutions of the developing countries for many years. NUFU's overall cooperative arrangement since 1990 shows a laudable achievement. Out of this, the University of Oslo has one of the biggest shares, as it is involved in many research projects and has established wide contacts with higher education and research institutions of the developing countries. As per 1996 NUFU statistics, Norwegian universities had established contacts with various countries (14 in Africa, 6 in Asia and 4 in Latin America). The cooperative research topics chosen were highly diverse and covered fields relevant to the developmental needs of the developing country in question. The fact that most cooperative research projects had a training component for upgrading the manpower of the developing country, attests to the positive outlook by which the NUFU ideas were conceived.

A brief look at the distribution of NUFU's funds between the Norwegian collaborating institutions and those in the South shows an overwhelming bias towards the South. Furthermore, the distribution of its support globally shows an obvious bias towards the highly needy part of the underdeveloped world, that is "sub-Saharan Africa". This region makes up more than 58% of all countries in the NUFU-assisted programs that receive 86% of the total funding. This shows one example of a strong commitment of a country from the North to assist the extremely backward economies of the South. The failure to benefit from the assistance could arise from either the lack of local capacity of countries of the South to make use of the assistance, or the system through which the assistance is delivered may be deficient structurally, administratively, etc. It is equally possible that although the statistics of distribution of funds are in favor of the aid recipient country, there could be an in-built system of control by the donor side that would make the apparent advantage of the recipient inconsequential.

11.5Academic Autonomy Necessary for North-South Collaboration: The serious deficiency of the collaborating universities or colleges of the South is the lack of

academic freedom and institutional autonomy. Academic freedom to teach or to learn or conduct research without interference of the government is a necessary precondition for a successful performance of the institution and for effective North-South university collaboration. Although the institutions of Northare known to enjoy academic freedom and autonomy, the situation within the Southern Institutions is not satisfactory.

The instability of governments of the underdeveloped South and the frequent shift in the priorities of these countries hamper developmental efforts. Furthermore, the shifting mandates given to the higher education and research institutions, makes it difficult to develop and implement collaborative projects. Universities and colleges of the South are faced with ever-shifting instructions, from frequently changing governments, to re-adjust their programs to accommodate the shifting developmental ideologies (philosophies). Such government interference keeps on disrupting the academic and research programs of higher education institutes. As a result of such infringement of academic freedom, the collaborating institutions of the South remain immature. This immaturity is reflected heavily in poor systems for management of project resources, which frequently frustrates project implementation.

In addition to the lack of academic freedom, the poor working conditions and the substandard remuneration has been forcing many scholars and scientists from the South to immigrate to the North, or change jobs. This would result in premature changes of counterparts from the South, thus introducing disruptions in the conduct of the collaborative North-South development projects.

In the Southern collaborating institutions (far more than what is experienced in the North), project finances are subjected to cumbersome bureaucratic control that government finances are subjected to. This has been one of the main frustrations to the researchers. The seriousness of financial management problems has been documented by certain project review teams from the North and has been determined to be the biggest bottleneck in project implementation.

It is frustrating for the researcher when the university bureaucracy dictates how much of the funds is to be released for use, and when. The extremely complicated and absurdly slow purchasing, customs clearance and project personnel employment procedures are so daunting that, once one has experienced it, no researcher wants to face it again. This is a serious disincentive to a researcher from the South for engaging in any research project and seeking support for it.

Looking at NUFU again, whereas NUFU operates as a coordinating unit for the activity of all universities and colleges on the Norwegian side, the situation within the recipient South is fragmented. As a result of lack of coordination of the training and research activities, at times, there is an unhealthy competition for the limited resources made available by the North. Duplication of efforts with other donor-

supported programs is encountered occasionally. Such lack of coordination of support programs results in duplication of support, leaving other priority areas unattended.

The initial installing, maintenance and repair of project equipment is a serious problem that frustrates project implementation in accordance with the project plan. The poor technical literacy within the institutions of the South and the lack of service providers in the local market seriously impede the development project work. It is a waste of highly valuable and limited resources, when a piece of expensive high tech equipment purchased for the local component of the project cannot be used for the proposed activity. The bitter experience most researchers have is that, dictated by such limitations to make use of the imported pieces of equipment, the originally proposed activities are relocated to the collaborating institution in the North. Such decisions to revise the project implementation plans are dictated by the pressure to prove the productiveness of the project through generation of data. The project managers are put under great pressure to demonstrate concrete achievements in their regular reports. This has been forcing the project managers to present lame justifications for failing to implement the Southern component of the work originally scheduled. Thus, by default, the original idea of local capacity building through technology transfer is compromised. The whole project is refocused on meeting schedules such as generation of publications (regardless of where the data is generated) or having a Ph.D. candidate complete the training, regardless of whether the original development project idea is met or not. In this scenario, two unfortunate events, which were not intended in the original project proposal develop. One, the Southern institution has unwittingly served as a conduit to transferring research materials which the institution in the North would not have access to otherwise. In the absence of well formulated modalities for research material exchange and use, question of intellectual and patent rights becomes sensitive. Secondly, the original project idea has been extensively modified and the collaborator from the North (project finance manager) has taken over the whole project to the marginalization of the collaborator from the South.

Autonomy of the Southern collaborating institutions from their Northern collaborators must be ensured to cultivate partnership in ways that replace the specter of paternalism with the spectrum of equalities. Northern and Southern counterparts possess complementary intellect. However, the tendency of some Northern counterparts to unilaterally decide on project issues and expect the Southern counterparts to accept negates this. At times the collaborating institutions from the North have been trying to tell their Southern collaborators what to do, and how they should run their programs. This jeopardizes the autonomy of the collaborating institution from the South. This can be avoided if the planned project activities in the South are implemented according to the original program. Furthermore, the terms of collaboration between the Northern and Southern institutions must be clear and unambiguous to avoid confusion

during project implementation.

Poor understanding of the policies of the Southern institutions by the collaborators from the North could lead to an unfortunate interference of the Northern collaborators in the internal affairs of the South. Such measures would compromise the very purpose of North-South collaboration, that is, capacity building within the Southern institution and assisting Economic Development in the South. Such irregularities can be avoided by drafting careful and conscious terms of understanding for the collaborative programs.

The premise that the North supports areas of economic development and knowledge transfer that are the South's national priority is a noble principle. However, a closer examination of the implementation of that principle reveals a major flaw in practice. The biggest flaw is that at times to obtain North's funding, it has been mandatory that the so-called national priority areas of the South must also be a field of interest of a Northern counterpart. This being a precondition for initiating funding through North's support, places a serious limitation on the kinds of projects to be supported. As a result, although the projects that fall within the interest of the North counterparts may be considered to be within national priority, in the broader sense, they may not be among the top priority areas of economic progress for the South countries. For the North to continue providing vital knowledge support to the institutions of higher education and research in the South, stringent government and bureaucratic control must be minimized. It must be borne in mind that better communications and understanding can be achieved more easily and readily between academics than between bureaucrats and academics.

12. CONCLUSIONS

It is more important than ever for developing countries to move ahead in scientific and technological development at an accelerated pace. Doing so will enable them to build science and engineering local capacity that can help solve the many problems they face. It will also enable them to take an active part in the global knowledge economy. The biggest hurdle in some of the developing countries is the lack of appropriate infrastructure and infrastructure services. A well established infrastructure provides a basis for technological innovations in all sectors of economy. More often, the infra-structure and technological innovations reinforce each other and must be included in any science and technology policy. A glaring example of this phenomenon is the rapid development of Information Technology which could not have taken place without the existence of a sound telecommunication infra structure. Reliable electric power, efficient logistical networks and a good transportation system are the prerequisites for any technology to be successful. A well established infrastructure, appropriate to the local conditions and consistent with ecological system must also provide efficient infrastructure services which are essential for attracting foreign investment. These services may vary with countries and should be appropriately chosen to support the

economic and industrial activities.

National standards must be laid down in accordance with the international bench marks for the developing countries to participate in the global economy. Investment in science and technology has been one of the most effective tools for economic transformation in the newly industrialized countries East Asia. Universities have a great potential to promote technological development provided they are not ill equipped and suffering from shortages of funds. Universities, throughout the world are assuming a new role for meeting the challenges of sustainable development. The promotion of higher education has its value, but attention must also be paid to primary and secondary level education, which constitute the formative years of an individual's life. Many developing countries have neglected the training of technicians and technologists and crafts people who have an important role to play in adapting new technologies. Vocational and polytechnic institutions need to be started to train people who do not wish to pursue higher education and can quickly find employment or may start a small business on the basis of the acquired knowledge. This would certainly reduce the unemployment problem and help in poverty alleviation.

13. RECOMMENDATIONS

a. Good partnership should be flexible and developed over time. Therefore, North must focus first on direct assistance, without government (North or South) interference, to the Southern institutions, whether private or public or industrial or academic, to build their basic indigenous capacity.
b. North should help establish links between Northern scientists and those in the South by sponsoring short term professional visits. This will create the necessary environment for initiating a fruitful North-South collaboration.
c. Institutions of the South must strive for more autonomy and improve their overall management system to best benefit from the assistance from the North.
d. In view of the fact that developmental needs of the South are so extensive, it is necessary for the North to expand direct support to governments, independent researchers and institutions in the South in an equitable manner.
e. North-support receiving universities and research institutions in a country must form a coordinating consortium to jointly plan their research activities to avoid duplication of efforts and competition for funds.
f. With the view to strengthening regional cooperation in development, cost effectiveness and minimizing the risk of brain drain, North must support and encourage more South-South collaborations in training and research.
g. In the same manner that applies to the Northern collaborators, the counterparts from the South must also be remunerated for the time spent on the joint projects through the funding institution of the North. This would serve as an incentive to keep the counterparts from the South much longer in the projects.
h. Governments (North or South) must play the role of facilitators in all facets of the North-South collaboration.

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KNOWLEDGE-BASED ECONOMY & DEVELOPING COUNTRIES: *A New Approach to Development*

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1. TRANSITION FROM TRADITIONAL ECONOMY TO KNOWLEDGE-BASED ECONOMY

For countries in the vanguard of the world-economy, the balance between knowledge and resources has shifted so far towards the former that knowledge has become perhaps the most important factor determining the standard of living—more than land, than tools, than labour. Today's most technologically advanced economies are truly knowledge-based. (World Development Report, 1999)

For the last two hundred years, neo-classical economics has recognised only two factors of production: labour and capital. Knowledge, productivity, education, and intellectual capital were all regarded as exogenous factors, that is, falling outside the system. *New Growth Theory* based on the work by Stanford economist, Paul Romer and others, deals with the causes of long-term growth, something that traditional economic models have had difficulty with. Following the work of economists, such as Joseph Schumpeter, Robert Solow and others, Romer has proposed a change in the neo-classical model by considering technology (and the knowledge on which it is based) as an intrinsic part of the economic-system (Romer, 1986; 1990).

That knowledge plays an important role in the economy is not a new idea. All economies, however simple, are based on knowledge about how to farm, to mine and to build; and this use of knowledge has been increasing since the *Industrial-Revolution*. But the degree of incorporation of knowledge and information into economic activity is now so great that it is inducing quite profound structural and qualitative changes in the operation of any economy and is transforming the basis of competitive-advantage.

The rapid development of the Internet, especially in the past ten years, has resulted in the escalation of global economy. This globalization has had a profound impact both on the economies of nations and the pressures on countries to compete effectively in this new environment. This new trend has also meant that countries should compete on a global scale. In this new environment two of the most important components for a nation are information and knowledge.

The knowledge-based economy is emerging from two defining forces: Knowledge-

intensity of economic activities, and the increasing globalisation of economic-affairs. Knowledge-intensity is being driven by the combined forces of the revolution of information technology (I.T) and the increasing pace of technological change. Globalisation is being driven by national and international deregulation, as well as the revolution in ICTs. However, it is important to note that the term *'Knowledge-Based Economy'* refers to the overall economic-structure that is emerging, not to any one, or combination, of these two forces.

The rising knowledge-intensity of the world's economy and the increasing ability to distribute that knowledge has raised its value too all the stakeholders in the economic system. The implications are profound, not only for the strategies of firms and for the policies of a government, but also for the institutions and systems used to regulate economic behaviour.

The transmission of knowledge and scientific and technological advances across national borders is growing and is facilitated by advances in ICT. This, in turn is manifested in the growing trend of the internationalization of scientific and technological activities. However, countries differ in their capacities to capitalize on the opportunities thus are derived from scientific and technological advancements. Countries that lack the capacity and capability to access global knowledge and new technologies, to utilize them for their productive activities will remain marginalized.

2. CURRENT SCENARIO OF DEVELOPING COUNTRIES

The development-community is increasingly recognizing the importance of knowledge for economic-growth and reduction of poverty. The traditional view that development depended on natural resources and capital-accumulation held true in the transition from agricultural economies to industrial economies, and it still holds true in the transformation from agricultural and industrial societies to knowledge-based societies. However, the technological revolution, centered on information-technology, is now reshaping societies to a base on access to information and knowledge.

The overall lack of structural change, the very slow rate of productivity-growth and the limited range of goods in which developing countries are internationally competitive, are all symptomatic of a lack of technological learning and innovation within developing countries. The patterns of production and trade indicate that the level of accumulation of knowledge-based assets is generally low. Using traditional indicators of technological effort (such as R&D, patenting, numbers of scientists and researchers and publications), it is apparent that there is a major "knowledge" divide between the developing countries and developed countries.

Their existing production and trade structures offer very limited opportunities in a rapidly globalizing world driven by new knowledge-intensive products with demanding conditions of market-entry. At the same time, rapid opening up in more traditional sectors is exposing existing producers to an unprecedented degree of global

competition. Benefiting from recent technological advances requires advancing towards and crossing various thresholds in human capital, R&D and management-practice, for which most developing economies lack the resources to do.

Developing countries are hampered by weaknesses of key elements of knowledge-based economies, namely adequate levels of educational attainment, the business environment and the information infrastructure. The statistics show that R&D expenditure in developing countries is very low, compared with that in OECD countries. Gross expenditure on R&D in 2003 (or the latest available year) was 0.3 per cent of GDP in developing countries, compared with 2.2 per cent of GDP in OECD countries. The number of researchers and scientists engaged in R&D activities per million population in the developing countries in 2003 (or the nearest year) is around 10 percent of the level in OECD countries. Between 1991 and 2004, an estimated 14,824 US patents were granted to citizens of developing countries, as compared to 1.8 million to the citizens of OECD countries. The basic weakness of human resources within the developing countries, indicated by the general statistics on years of schooling and the brain-drain, shows the inadequate of the social basis for building technological capabilities. This is also apparent in technically-related education. In 2001, technical and vocational education constituted only 10.4 per cent in developing countries, against 25 per cent in OECD countries. Enrolment in tertiary technical subjects is very low. In recent years, tertiary enrolment was equivalent to only 23 per cent of the population aged 20–24 in developing countries, as compared to 57 per cent in high-income OECD countries. Tertiary-level enrolments, particularly in technical subjects, are important for developing the managerial and technical skills to use modern technologies efficiently and to adapt imported technologies to local conditions. This indicates a major gap in the general competences which provide the basis for technological capabilities. In recent years, many developing countries have achieved higher rates of economic growth than in the past and even higher growth of exports. But there is a widespread sense that the developing countries are at a critical moment of transition, in which they face many challenges. More and more people are seeking work outside agriculture and the trend of urbanization is accelerating. For the developing countries as a group, the decade 2000–2010 is going to be the first decade in which the growth of the economically active population outside agriculture is predicted to be greater than the growth of the economically active population within agriculture. This transition will affect more than half the developing countries during the decade and even more in the subsequent decade 2010–2020. (UNCTAD, 2006)

Knowledge-driven development has emerged as an important engine of growth and poverty-reduction, and the elements of the knowledge economy are already quite visible in developing countries like China, and India—which are home to 45 percent of the world's population. However, these elements manifest themselves in different ways. The information-technology software and services industry in India, for example, has caught the imagination of the world, and is currently accounting for almost 2 percent of India's GDP. China has several flourishing high-tech parks along its coast that are hotbeds of innovation. However, these are only a few of the more

impressive examples. Knowledge is increasingly becoming a key factor of development, and the "knowledge economy" is in no way purely confined to information and communications technologies (ICTs) or high-tech industries. It is defined as one where knowledge is created, acquired, transmitted, and used more effectively by enterprises, communities, and individuals, for greater economic and social development. Such an economy taps and uses the growing stock of knowledge and advances in ICT for its overall development. The following case studies are selected as exemplar, to show that knowledge is the most critical factor for competitive advantage in the K-Economy. The infrastructure from economy must enable the generation, acquisition, and utilization of knowledge in supporting sustainable development and economic growth.

3. CASE STUDY-1: CHINA'S DEVELOPMENT STRATEGY: THE KNOWLEDGE AND INNOVATION PERSPECTIVE

For a large part of the last two millennia, China was the world's largest and most advanced economy. Then it missed the Industrial Revolution and stagnated. Only after opening to the outside world in 1979 was China's economic performance again impressive. And its achievements in increasing welfare and reducing poverty are unparalleled. But China cannot sustain such progress without major changes in its development-strategy, as elaborated recently in the tenth five-year plan. China faces daunting internal challenges, compounded by the knowledge and information revolution. To overcome these challenges, the Chinese government must take on a new role to quickly exploit the knowledge-revolution—architect of appropriate institutions and provider of incentives to promote and regulate a new socialist market-economy based on knowledge.

This study is a brief analysis of the transition of China's economy to bring about considerable technological advances in the nation and to lead to knowledge-revolution. It is a great example of a country considered to be in a developing phase which is undergoing a transformation from traditional economy to knowledge-based economy to meet the global competition. It outlines the main challenges that China faces in its future development, and the importance of shifting from a factor-based to a knowledge-based strategy. This study has been prepared by Carl Dahlman & Jean-Eric Aubert of World Bank Institute.

3.1 Main Issues

China has made great progress since it opened its economy two decades ago and began a transition to a market economy. An extraordinary process of modernization has taken place, particularly in the coastal areas and cities. New industries have been developing fast, enormous progress has been made in the business environment, and the country has considerably improved its participation in the global economy, in which it is now a major player. However, important challenges lie ahead. These stem from a more demanding international environment, as well as from specific

characteristics of China's current stage of development.

A knowledge-revolution, brought about by considerable technological advances (in information and telecommunications but also in life sciences, material sciences, etc), is taking place world-wide, deeply affecting economies and societies. It is also dramatically increasing the global competition. China's continuing transformation from a rural, agricultural economy to an urban, industrial and service economy creates strong pressures for continuous restructuring. These pressures will be compounded by the knowledge-revolution and accelerated by China's greater internationalization through accession to the World Trade Organization. We estimate that some 90 million new urban jobs will have to be created within the next ten years, to absorb labor shed by the rural areas, compensate for job-losses related to the economic restructuring, and provide the additional jobs induced by the projected increase in the labor force.

3.2 Knowledge-Based, Rather Than a Factor-Based Strategy for Development

To cope with the challenges brought about by the knowledge revolution and increased international competitiveness, as well as the employment implications of the massive restructuring that China will be undergoing, a knowledge-based rather than the current factor-based strategy is needed. This knowledge-based strategy consists of making more effective use of new and existing knowledge and technology throughout the whole economy. There are four major pillars to this knowledge-based strategy:

- An economic and institutional regime that provides incentives for the efficient use of existing knowledge and the creation of new knowledge and entrepreneurship.
- An educated and skilled population that can create and use knowledge.
- A dynamic information-infrastructure that can facilitate the effective communication, dissemination, and processing of information.
- An effective system of innovation where enterprises, research centers, universities and other organizations interact effectively to create and diffuse technologies using the growing stock of domestic and global knowledge.

3.3 Policy Recommendations

The role of the government in the knowledge-economy is basically to promote and discipline markets and provide, or facilitate, investments in the necessary public goods, such as educational infrastructure, basic research, telecommunications, and innovation-networks. It is precisely on those points that we focus our recommendations. The socialist market economy regime has made an invaluable contribution to Chinese economy. However, in some areas, the right balance between State intervention and disciplined non-State actions, and between true market mechanisms and market-mimicking bureaucratic measures, is yet to be found. These issues are also rooted in deeper historical and cultural features of China. The

recommendations below point to a redirection of the role of the governments – both central and local –to improve the broader framework and to redirect the innovation system.

A. Improving the Broader Framework:

i. Upgrading the legal and regulatory environment
ii. Exploiting the information and telecommunication infrastructure
iii. Investing in higher education and training

B. Redirecting the Innovation System:

i. Expanding programs for Technology Dissemination
ii. Benefiting from global knowledge and technology
iii. Strengthening the research system

3.4 Implementation

In order to put in place a coherent and efficient action plan, it is deemed necessary to:

- Give local governments (provincial and city authorities) a prominent role in elaborating and implementing regional strategies and policies;
- Strengthen coordination capabilities, in the central government, to ensure effective policy integration among ministries and plans; and
- Improve the efficient use of the current state budget for innovation activities, viz:
  - establish effective monitoring and evaluation systems, and rationalize the current allocations of resources;
  - increase government of funding gradually, so that, by the third to fifth year of the Tenth Plan, an additional 10 billion Yuan per year is allocated to the support of the innovation system. This should be financed on an equal basis by local and central governments; three-fourths of the additional resources should be invested in technology dissemination efforts.
- Leverage the limited resources of the state by tapping private resources:
  - fund telecommunication infrastructure development largely by allowing entry of private domestic and foreign capital, and by auctioning rights to lucrative markets, along with obligations to provide low-cost service to marginal areas;
  - fund additional rapid expansion of higher education largely by tapping willingness of students to pay, and of private educational institutions to provide relevant higher education. A part of the public funding need could be met from the "demographic dividend" of having fewer school-children over the next 20 years.

The entrepreneurial spirit of the Chinese people is considerable. Resources exist. The recommendations listed above are all eminently doable. In fact, Shanghai has essentially implemented virtually all of them already. The key is the political will to undertake reforms. Primarily, these have to do with continuing to improve the economic and institutional regime to release the entrepreneurial energy of the people and to create self-adjusting processes. Besides this, perhaps the most important step is to open up the telecommunications sector to competition, and to rapidly expand Internet access and use. Rapidly expanding access to information and communication will help to catapult China to become a knowledge-based economy. It will also help to make more transparent the existing inefficiencies in the system (such as the need for a credit system to do electronic commerce) and permit leveraging limited resources over a vast population (distance education, health services). What is thus required is a self-confident, proactive strategy to take advantage of the knowledge revolution. How far China will advance will depend on how fast it embarks on the course of required reforms.

At the start of this new century, we suggest that the slogan of the State as a 'Clever Regulator' be promoted by appropriate campaigns. This new role of the state is to develop markets and to set up institutions and procedures to discipline them, so that they operate effectively. It is also to address public goods issues, such as funding basic research and the articulation of networks, standards, and other mechanisms that may not develop very effectively without its catalytic, coordinating role. This image would replace the image of the visionary planner characteristic of the communist regime in the industrial era, and further back in history to the image of the wise administrator in the feudal regime of the agrarian-economy. In its new role, the state will be able to usher in a new wave of reforms which will help unleash the creative potential of the Chinese people.

4. CASE STUDY-2: KOREA AND THE KNOWLEDGE-BASED ECONOMY: MAKING THE TRANSITION

Here is another example, which is a joint study carried out by the World Bank and the Organization for Economic Co-operation and Development. The study breaks new ground in its attempt to develop a comprehensive set of national policy-responses to the knowledge-revolution.

Korea is a country with limited natural resources, which has developed mainly through an outward oriented, industry-led, strategy based on large firms and economies of scale. Today, however, this industrial paradigm is being challenged by the rapid rise of knowledge as the principal driver of competitiveness.

A. The Knowledge-Revolution: The Challenge to Korea's Developmental Strategy

4.1 Korea's Achievements

Korea has achieved one of the fastest rates of economic development of any country in

the world. Between 1966 and 1996, its per capita income grew by an average of 6.8% per annum (in constant 1995 USD), and it became an OECD Member in 1996. Towards the end of 1997, however, Korea experienced its worst economic crisis, since the Korean War. Nonetheless, Korea made a remarkable recovery from the crisis and its economy grew at 10.7% in 1999. The government expects some 6 - 8% growth in 2000 and in the following few years. However, this performance may not be sustainable. Irrespective of the crisis, Korea faces a difficult and competitive global environment. Its wages have risen and it is experiencing increasing competition from lower-wage countries in East Asia. Although its manufactured exports have been expanding rapidly, it is being squeezed between the developed OECD countries, at the higher end, and China and other East Asian developing countries, at the lower end. As a result of these developments and the increasing importance of knowledge, Korea is now confronted with the unprecedented challenge of transforming itself into a knowledge-based economy.

4.2 The Global Knowledge Revolution

Increases in scientific understanding and very rapid advances in information and communication technologies (ICTs) mean that knowledge and information have become keys to competitiveness. Technical progress and reductions in transportation and communications costs are leading to a more interdependent and competitive world. Investors are increasingly seeking first-mover advantages, new products and services, in response to customers' diverse and rapidly changing demands, speed to the market, with first-rate access to customers and sources of information. The rapid development of ICTs and the Internet is exposing inefficiencies in the functioning of markets, firms and institutions, putting downward pressure on prices and accelerating the need to restructure and adapt to changing conditions. ICTs are also improving the efficiency of interaction among government agencies and the delivery of government services, as well as facilitating consultation with the public. This is bringing a new potential for the re-organization of administrative and political institutions and for dramatic reductions in the cost of delivering services. In addition, new ways and means of networking are altering social patterns of work, shopping, education, leisure and communications.

In Korea, investments in education, information-infrastructure and in research and development (R&D) as a percentage of GDP are among the highest of the OECD economies. However, the country is not getting the full benefit of these investments because of problems with the overall economic incentive and institutional regime, as well as due to issues specific to each of these three areas. Reasons for this include:

- Inadequate conditions for generation and exploitation of knowledge and information (e.g. intellectual property rights and the regulatory framework with relation to IT).
- Insufficient competition, flexibility and diversity (e.g. the chaebol, the financial and education systems).
- Misallocation of investments (e.g. duplication of public investment in R&D,

insufficient public-investment in basic R&D, overinvestment in an education system, which is geared to simply passing exams).

These problems are serious since they cast doubt on Korea's capability to sustain its development process in the long-term, despite the resources invested and recent achievements. Korea has to move to a strategy of achieving greater productivity across the board.

This includes not only opening up to trade and foreign investment, but actually striving to become more integrated into the global system. This involves:

- Developing alliances with world-class universities, fostering the exchange of professors and students, and enhancing knowledge of foreign languages and culture.
- Tapping more effectively into global knowledge-systems through joint research, joint submissions to international journals, strategic alliances, inward and outward FDI, and contracting of foreign research institutes.
- More active participation and leadership in international forums and institutions, especially those that are setting the rules and practices for the new economy, such as the WTO, the World Intellectual Property Organization (WIPO), the International Standards Association (ISO), the OECD, etc.
- Ensuring harmonization with evolving international standards, including more active participation in the International Telecommunications Union, etc.

The Korean Government has played a key role in the country's rapid development and will indeed need to play an important role in the transition to the knowledge-based economy. Meeting the requirements of the knowledge-based economy means making markets function more effectively, so that they can facilitate the constant redeployment of resources. This simply cannot be done through heavy government intervention in the economy. The key elements of the new role for government in this context are:

- Unleashing the creative power of markets.
- Providing legal and regulatory underpinnings for free and more competitive markets – rule of law, standards for transparency and accountability, modern regulatory institutions.
- Building a modern legal infrastructure for the knowledge-based economy – intellectual property-rights; cyber laws, covering privacy, security, and digital transactions.
- Continuing to provide public goods (education, basic research), while addressing missing or underdeveloped markets (information networks).
- Fostering policies and institutions conducive to entrepreneurship and enterprise-development (facilitating entry and exit in a number of areas, including the removal of onerous regulations hindering the start-up of new businesses, especially in the service sector, promotion of high value-added

services, valuation of intangibles).

A new and important role for government will be to address the risks of the "digital-divide". The ICT revolution brings with it not only opportunities, but also the risk of creating a "digital-divide" between those who have access to the potential benefits of ICTs and knowledge, and those who do not. To offset the risks of a growing digital and knowledge divide, the Korean Government needs to adopt proactive policies, aimed at fostering the availability of information and knowledge services, and spurring widely spread entrepreneurial activity. It should pay special attention to using ICTs and new technologies to provide opportunities for rural and poor urban communities and the disabled. In addition, the government must modernize itself in order to capture efficiency-gains by improving the quality and effectiveness of public services and strengthening government information-flows. Since the crisis, the Korean Government has made a very impressive start in this direction. The next step will be for it to become a facilitator of change, fostering broad participation consistent with the distributed power arrangements of the networked economy.

4.3 Korea's New Vision

The Asian financial crisis has brought about a reexamination of Korea's structural problems, and a new willingness and energy to change the Korean economy and society. At the beginning of this year, the government articulated a long-term vision to transform Korea into an advanced knowledge-based nation. Goals include:

- Making Korea into one of the world's top-ten information and knowledge superpowers.
- Developing the next-generation Internet and the information superhighway.
- Promoting the use of computers by students, teachers and the military.
- Conducting radical reforms in education, to arm the country for its transformation into a knowledge-based economy.
- Envisioning the dawning of an Internet-society, where civil society will participate in the governance-process though ICT in a democracy based on human rights.
- Closing the development-divide through productive welfare and balanced regional development.

4.4 The Framework of the Knowledge-Based Economy

A knowledge-based economy is defined as one where knowledge (codified and tacit) is created, acquired, transmitted and used more effectively by enterprises, organizations, individuals and communities, for greater economic and social development. It calls for:

- An economic and institutional regime that provides incentives for the efficient use of existing knowledge, for the creation of new knowledge, for the

dismantling of obsolete activities and for the start-up of more efficient new ones.
- An educated and entrepreneurial population that can both create and use new knowledge.
- A dynamic information-infrastructure that can facilitate effective communication, dissemination and processing of information.
- An efficient innovation-system comprising firms, science and research centers, universities, think tanks, consultants and other organizations that can interact and tap into the growing stock of global knowledge; assimilate and adapt it to local needs; and use it to create new knowledge and technology.

This framework is used in the report to take stock of where Korea currently stands and to suggest further measures to facilitate its transition to an advanced knowledge-based economy.

4.5 Issues in the Four Key-Areas

The challenges identified above are systemic in nature. A major task for the government is to adopt a more comprehensive and consistent approach, which encompasses all the relevant policy domains. As an essential component of such an approach, reforms are necessary in the four areas discussed below, each of which contains deficiencies that have implications for Korea's ability to benefit from the knowledge-based economy.

Economic Incentive and Institutional Regime: The main challenge is to move away from direct intervention and to foster a flexible, adaptive, market-based economy and a creative society, compatible with the knowledge-based networked economy. This means placing high priority on reforms that will enhance competition and flexibility in the economy and unleash efficiency gains and innovation. It will require measures that can bring about a fundamental upgrading of the economy's capacity for spontaneous adjustment to changing competitive pressures and opportunities and for the effective utilization and creation of knowledge. Some traditional areas will have to be deregulated, while there is a need for establishing modern regulatory oversight in certain new areas in order to strengthen markets. While the government has already started on a series of important reforms, it needs to embark on a systemic agenda for reform across a number of areas, including:

- Product markets: strengthen foreign and domestic competition, consumer protection and standards.
- Financial markets: ensure greater transparency and disclosure, strengthen corporate governance, accounting-rules, prudential-supervision, improve equity and venture capital-markets.
- Labor markets: improve labor relations, make worker benefits portable and remove employment biases against women.
- Knowledge market: strengthen intellectual property-rights, their

enforcement, and the promotion and valuation of intangible assets.

- Industrial restructuring and entrepreneurship: put in place policies and institutions for spontaneous industrial restructuring and development, including the fostering of entrepreneurship and a more favorable performance of small and medium-sized enterprises.
- Social issues: mitigate the risks of the "digital divide" by upgrading social safety nets, strengthening opportunities for retraining, and extending access to education and information infrastructure to poor urban and rural communities and to the disabled.
- Education, Training and Human Resource Management

The time is thus ripe for Korea to switch to a new model of education that promotes quality, creativity and lifelong learning, and that emphasizes not just formal schooling, but overall human resource development. This will entail major deregulation, decentralization and diversification of the Korean education system and enhancement of competition.

Information-Infrastructure: The ICT revolution will increasingly affect the efficiency and functioning of all economic and social activities. Korea has moved a long way toward liberalizing the ICT sector and is thereby capturing many of the benefits of advancing technologies. In addition, there has been a very rapid uptake of new information technologies such as mobile phones and the Internet. However, the country has a regulatory regime that may constrain continued fast development: the Ministry of Information and Communications (MIC) still tries to orchestrate much of the sector's development when, in reality, the market is moving more rapidly than the regulator can successfully anticipate. Thus, the MIC should move further toward facilitating private provision of services and addressing areas of market failure. In particular, it should:

- Liberalize the telecommunications service industry, unbundle local loop services, set up an independent regulatory agency, and open up to greater foreign investment.
- Develop a modern regulatory oversight for telecommunications that includes interconnection standards, service quality and auctioning of spectrum.
- Implement legislation on regulation of e-commerce that is harmonized with evolving international standards.

Innovation-System: Korea reportedly spends more on R&D than most other OECD countries as a percentage of GDP (2.8%). However, the productivity of this effort is questionable on the basis of various indicators of industrial competitiveness, technical creativity and scientific production. There are some inherent weaknesses in the Korean innovation system that needs to be addressed. The government has recognized the challenge and has announced plans to increase R&D expenditures to 5% of the national budget – an ambitious target which signals the seriousness of its resolve. However, it is not so much a matter of the amount of money spent as the way in which it

is spent. Key issues in this area include:

- Encouraging greater interaction among firms, universities, government research programs and Government Research Institutes (GRIs).
- Clearly justifying the rationale for public intervention and providing subsidies in a transparent and non-discriminatory manner.
- Providing support to R&D in large companies on stricter conditions, assisting only when they would not have undertaken the concerned projects in the absence of support, and stimulating partnerships with other actors (enterprises, university and public laboratories), etc.
- Increasing the basic research effort. This measure should principally target the universities, which should receive larger resources; it implies reforming regulations and practices that discourage research activities.
- Reorienting the GRIs since their activities tend to duplicate those of industry. The GRIs have to be re-positioned to do more upstream research or to become more focused on research of collective interest (e.g. health, transport, etc). A larger part of their budget has to be secured in the form of institutional funding.
- Improving support to innovation in SMEs, with emphasis on effective networking and clustering, and the involvement of local authorities.
- Strongly encouraging all actors to increase their contacts with foreign counterparts, through academic and research exchanges, technological co-operation, industrial joint ventures, participation in international regulatory bodies, etc.
- Enforcing co-ordination procedures involving key ministries.
- Implementing evaluation exercises, including an international review of the country's basic research capacities.

4.6 Implementation of the Reforms

The reform strategy outlined above has to be systemic and must involve the design and implementation of measures which are consistent across different, traditionally disparate areas of policy making. The government has a significant role to play in making sure that all groups are well informed about the trends and forces affecting them and the need for change.

Based on the experience of other countries that have crafted and implemented broad strategies, such as Canada, the United Kingdom, Ireland and Finland, it is clear that the development of the strategy must be undertaken in consultation with the private sector and civil society. This is particularly relevant for Korea, given the current social and political change that is taking place and the vision for the country in the 21st century enunciated by the government. The public hearings and consultations with think tanks and the private sector on national policies and reforms that have taken place so far represent an encouraging trend.

However, building consensus and buy-in from stakeholders on the desired measures requires a greater effort of dissemination, explanation and consultation with the wider public, including civil society. To illustrate, the education sector must implement major reforms – many of which have already been formulated by Korean think tanks and concerned groups. Much initial resistance is likely to come from the education agencies and from teachers, as both parties would lose some degree of power and control. It will be important to convince these groups of the benefits of the reforms.

Implementation of the strategies should also focus on whether the infrastructure to implement reforms is in place. Too often, across countries, strategies and initiatives are announced without the adequate evaluation systems and staff in place. Because of the dynamic nature of the knowledge and information revolution and the global-economy, it is important to set up a monitoring and evaluation system as an integral part of the implementation process. It will also be necessary to build in provisions for adjustments to plans and actions in light of ongoing developments, including the findings of impact evaluations.

There is a tension between the need for some centralized locus of responsibility for overall co-ordination of the strategy and its implementation, on the one hand, and the distributed power arrangements of a networked economy, on the other. An appropriate balance has to be found in the Korean context.

These are preliminary suggestions and should be treated as points for more intensive discussions. Which Korea has to set up for itself, analyzing where it currently stands, where it wants to go, and how it is going to get there. Such a process has to be owned not only by the Korean Government, but by the Korean people.

5. CASE STUDY-3: TRANSFORMATION INTO A KNOWLEDGE-BASED ECONOMY - THE MALAYSIAN EXPERIENCE

Recognizing the significant need for knowledge as input, Malaysia has embarked on the transformation from an input-driven growth-strategy (that had served her well in the past) to one that is increasingly driven by knowledge, in order to achieve sustainable high growth and development. The shift to the k-economy is part of a wider plan to achieve the objective of the nation's Vision 2020. Dr. Jamaludin Mohd Jarjis, Minister of Science, Technology and Innovation of Malaysia (2006) describes the present scenario of Malaysia being in the phase of transition into knowledge-based economy.

The transmission of knowledge, know-how and technology across national borders is growing and is facilitated by advances in information and communication technology (ICT). This in turn is manifested in the growing trend of the internationalization of scientific and technological activities. However, countries differ in their capacities to capitalize on the opportunities derived from scientific and technological advancements. Those that do not have the capability and capacity to access global

knowledge and new technologies and utilize them for their productive activities will remain marginalized. Malaysia's vision and strategies for the development of the knowledge-based economy, as well as the challenges that are faced in the development path, are shared below.

Malaysia has come a long way starting with an economy dependent on agriculture and natural resources. In the early years the export of raw materials, namely rubber and tin, was the main source of national income. For these sectors, land and low-skilled labor were the main factors of production. Tertiary education was almost non-existent and only a small group of the population with the financial capacity was able to acquire tertiary education abroad.

Malaysia's transformation into an industrial or production-based economy in the 1960s led to major changes in physical infrastructure, financial system and educational-system. The Government invested in transportation infrastructure to move goods and services, financial and fiscal incentives to attract foreign investments, and education and training systems to supply the industries with skilled labor and technical workforce. Malaysia's investments in providing world-class infrastructure, attractive incentives and sound educational-system, have paid well in terms of export earnings from manufactured goods, in particular electrical and electronic products as well as foreign direct investments (FDIs). During the period from 1991 to 2005, Malaysia's exports grew at an average annual rate of 13.5 per cent and today Malaysia is the eighteenth largest trading nation. The FDI inward flows have been substantial.

Malaysia's efforts so far may be adequate if it can continue to leverage on low-cost skilled and technical workforce as a major comparative advantage. Unfortunately, this is not the case, as it faces growing competition from countries with abundant workforce such as China and India. At the same time, the role of knowledge is becoming increasingly critical in the new economy, as technology becomes more complex and economic growth is driven by knowledge-intensive industries.

Malaysia is fortunate in that it has a leadership that is fully committed to develop a nation that is progressive, resilient and competitive. Malaysia's national vision, namely Vision 2020, was introduced in 1990 with the goal of attaining a developed nation status by the year 2020. One of the key challenges of Vision 2020 is to develop a strong foundation for science and technology such that Malaysia will not only be a user of but also a contributor to scientific and technological advancements.

Malaysia has just fifteen years to go to achieve its national vision. It is gearing itself for the transformation into a knowledge-based economy or K-Economy, that is, an economy driven by knowledge and innovation. Strategies and approaches for a K-Economy would have to be different from those adopted to develop an industrial or production-based economy. Physical infrastructure that is critical for an industrial economy is no longer a major determinant for success in the K-Economy. Instead, the K-Economy requires investments in the Knowledge Infrastructure.

As knowledge is the most critical factor for competitive advantage in the K-Economy, the infrastructure must enable knowledge generation, acquisition, and the utilization of knowledge to produce goods and services that are competitive in the global market. Thus, Malaysia would need to invest in the Knowledge-Infrastructure that consists of:

i. An educational system, designed to produce a large pool of qualified and skilled workforce in science, technology and engineering, and other innovative, creative and enterprising professionals;
ii. A research and development (R&D) system, able to generate knowledge at the frontiers, as well as new technologies demanded by the production and services sectors;
iii. A strong intellectual property (IP) regime, that provides effective protection and appropriation of intellectual property rights;
iv. A technology-transfer system that ensures efficient transfer of knowledge and technology from the R&D system to the industry and business sectors;
v. A critical mass of innovative firms and entrepreneurs, to exploit knowledge so as to produce goods and services for the local and global market;
vi. A financial system, that promotes investment in high-risk ventures; and
vii. An eco-system, that facilitates knowledge-flows and promote interaction between and among the systems mentioned above.

Malaysia has just recently launched its Ninth Malaysia Plan which sets out the developmental plan and strategies for the period from 2006 to 2010. This is the first step in the next fifteen years journey towards a developed nation status. Following are the strategies and measures that have been identified to implement the national development plan.

Firstly, Malaysia will focus its attention on strengthening the National Innovation System (NIS). The National Innovation Council (NIC), with the Prime Minister as Chairman, will provide the leadership to set the direction and the implementation framework for the National Innovation Agenda.

A strong NIS will facilitate Malaysia's integration into the global technology and knowledge-creating network. As technologies become increasingly complex and the cost of creating new knowledge and technology rises, firms adopt strategies to reduce cost, through outsourcing of some of their innovative activities. Developing countries with relatively low cost but highly qualified human-resource can take advantage of this opportunity to undertake the outsourced activities. In this respect, Malaysia is developing the infrastructure and capability to take advantage of these outsourcing activities.

In the ICT sector, cost competitiveness, highly educated and skilled workforce, pro-ICT government and world-class infrastructure make Malaysia an obvious choice for activities, such as, shared services and outsourcing (SSO). The SSO cluster in the Multimedia Super Corridor (MSC) is ranked at number three in the world after China

and India. The MSC initiative launched in 1996 was aimed at attracting leading ICT companies to locate in the MSC and undertake research, development of new products and technologies and export from this base. A set of innovative-incentive package comprising fiscal and non-fiscal incentives are provided to MSC status companies.

As an 'open-economy', Malaysia has attracted large inflows of FDIs and transnational corporations (TNCs) especially in the electrical and electronic sectors. The infrastructure and incentives to attract FDI in the knowledge-based industries are different from those required for the production economy. It is vital that Malaysia strengthens its NIS to compete with countries such as China and India for FDIs. Recent trends that point to increasing internationalization of R&D activities of the TNCs will benefit those countries that have an enabling environment, in particular the availability of human-capital and R&D infrastructure as well as to motivate TNCs to conduct their R&D in the host countries. In this regard, human-capital development is central to Malaysia's development plan, in particular human-capital to enable effective harnessing of science and technology for creation of wealth and societal well-being.

At present Malaysia lacks the critical mass of qualified scientists, engineers and related professionals that are needed to drive the K-Economy. In 2004, Malaysia had only 21 research scientists and engineers (RSEs) for every 10,000 workforce. The target set in the Ninth Malaysia plan is to achieve 50 RSEs per 10,000 workforces by the year 2010. The shortage of RSEs will be somewhat mitigated, in the short term, with the implementation of the 'National Brain Gain Programme'. The objective of this Programme is to attract scientists and engineers worldwide to conduct R&D in Malaysia.

Malaysia views international strategic partnerships as an effective means to access frontier knowledge and accelerate scientific and technological advancements. In this regard, Malaysian universities and research institutions have been actively engaged in collaborative development of research and technology with centers of excellence in both the developed and developing countries. We look forward to enhance our cooperation with EU countries.

While the acquisition of knowledge through collaborative R&D projects, as well as attachments of Malaysian scientists and researchers in renowned research centers, are further expanded, at the same time, significant allocations are devoted to developing Malaysia's own centers of excellence in areas of strategic importance. For example new centers of excellence in genomics, agriculture biotechnology, and pharmaceuticals and nutraceuticals have been established recently to catalyze the development of a strong scientific base in biotechnology. The government of Malaysia has launched the National Nanotechnology initiative.

The Government of Malaysia realizes that building a strong scientific base and increased investments in R&D are not sufficient to drive the transformation to the K-

Economy. An equally if not more crucial requirement is to promote the creation of a large pool of innovative firms and entrepreneurs. It is the private enterprises that have the capacity and business aptitude to exploit knowledge and new technologies for economic gains. It is, therefore, crucial that private enterprises are given incentives to exploit knowledge and technology generated from research laboratories so as to generate new products and services for the local and global market.

The Government of Malaysia provides various types of fiscal and non-fiscal incentives to private enterprises to promote their involvement in R&D and innovative activities. The mechanism for funding of R&D and the commercialization was recently restructured to plug the financing gaps, in particular financing for development and pre-commercialization activities. Three new funds have been created, namely, Science, Techno and InnoFund. These funds are open to both the public institutions and private-sector enterprises. Firms that undertake R&D are also eligible for double tax deduction.

The lack of entrepreneurs has been identified as one of the weaknesses of the Malaysian innovation-system. The Government of Malaysia has introduced various programmes to address this weak link in the NIS. For example, in the ICT sector, a technopreneur development programme has been implemented in the MSC. With respect to the technology-based sectors, technology incubator facilities have been provided by the Government to create the critical mass of entrepreneurs, as well as to catalyze the creation of new technology-based firms.

While attention is turned to developing new technology-based enterprises, the Government gives equal attention to the small and medium enterprises (SMEs) that make up more than 90 per cent of enterprises in Malaysia. With respect to SMEs, the emphasis is on upgrading their technological capabilities, to enable their integration into the global production network. One of the measures taken is through support-programmes that enable SMEs to use new and advanced technologies including ICT in their production and business processes. A new element in the SME blueprint is the development of SME in the knowledge-based industries.

In transforming Malaysia's economy to one driven by knowledge and innovation, the Government of Malaysia is fully aware of the possibility of creating economic and social divide among regions as well as its population.

It has been recognized that ICTs have an important role to play in overcoming socio-economic inequalities, provided appropriate mechanisms are implemented to ensure that ICT are used for this purpose. Developing countries should not only invest in connectivity and access to ICT but give equal emphasis on socio-economic inclusion programmes. Accordingly, Malaysia has developed a framework that focuses on the value that ICTs are capable of delivering to underserved sections of the Malaysian society.

Malaysia's policies for ICT sector based growth have been in place for some time and are at the core of the country's ICT strategy in realizing Vision 2020. The focus so far has been more on infrastructure-development than on the issues of e-inclusion. A revised approach targeting e-inclusion implies the adoption of key socio-economic developmental objectives by ICT programmes in areas such as health, education, agriculture and rural-enterprise development and local content development. The Framework for digital-value divide when fully implemented will be a key vehicle for attaining e-inclusion in Malaysia, which in turn will have the effect of accelerating Malaysia's progress towards attaining the developed nation status by the year 2020.

Finally, one of the world's largest economies, and a developing country, India has made remarkable strides in its economic and social-development in the past two decades and is poised to realize even faster growth in the years to come. The time is very opportune for India to make its transition to the knowledge economy—an economy that creates, disseminates, and uses knowledge to enhance its growth and development. The knowledge economy is often taken to mean only high-technology industries or information and communication technologies (ICTs). It would be more correct, however, to use the concept more broadly to cover how any economy harnesses and uses new and existing knowledge to improve the productivity of agriculture, industry, and services and increase overall welfare. In India, great potential exists for increasing productivity by shifting labor from low productivity and subsistence activities in agriculture, informal industry, and informal service activities to more productive modern sectors, as well as to new knowledge-based activities—and in so doing, to reduce poverty and touch every member of society. India should continue to leverage its strengths to become a leader in knowledge creation and use. To get the greatest benefits from the knowledge revolution, the country needs to press on with the economic reform agenda that it put into motion more than a decade ago and continue to implement the various policy and institutional changes needed to accelerate growth.

6. OVERVIEW – NEW OPPORTUNITIES & CHALLENGES

The world is rapidly moving towards information and knowledge intensive societies. Developing countries are, by nature, problematic, characterized by poor business and governance conditions, low educational levels, and mediocre infrastructure. This raises particular challenges for the encouragement of knowledge-economy. What matters first is to provide the necessary package of support – technical, financial, commercial, legal, and so on – with flexible, autonomous agencies adapting their support and operations to the different types of concerned enterprises. Facilitating and responding to the emergence of grass-root needs at the local level is also essential. It is of primary importance to pay the greatest attention to country-specificities, not only in terms of development level, size, and specialization, but also in terms of administrative and cultural traditions. At the global level, major issues need also to be considered and dealt with by appropriate incentives and regulations: the role of foreign direct investment in developing countries' technological development, conditions of

technologies' patenting and licensing, the North-South research asymmetry, and brain-drain needs. The situation is, however, rendered more complicated because the "developing world" presents very diverse situations in terms of levels of development, culture, etc. Consequently, Knowledge-revolution schemes have to be tailored to countries' specific characteristics in line with the recognized fact that "one size does not fit all", and the recognized need for working much more on national peculiarities in all walks of development economics and policies.

This new era presents the developing world with both challenges and opportunities. These challenges are accentuated by the fact that the development process requires more knowledge and entrepreneurial spirit to compete in an environment of intensified global competition. The opportunities arise from the possibilities for modernization of traditional activities offered by new technologies.

The following illustrate some of the methodologies that governments are evolving to ensure that their knowledge economies to thrive in the competitive and innovative global economy. The tools needed for the knowledge-economy include information policies, that give citizens equal and universal information-rights so that all, not just a privileged few, shall benefit in the new economy. This is a major challenge facing any groups in society who are seeking wide and effective access to government information, as most countries in the developed world have poor or inadequate information policies & infrastructure.

IN SUMMARY, TO BE SUCCESSFUL AS A KNOWLEDGE ECONOMY, GOVERNMENTS NEED TO:

a. Develop programs to create an environment to promote knowledge-workers. Education is the key in this process, starting with front-end entrance institutions to higher education institutes;
b. Invest in technology to build infrastructures;
c. Build programs to fuel innovation and creativity;
d. Enact legislation to create security and confidence for businesses to operate in the growing knowledge-economy;
e. Develop information-laws which extend the information rights of the citizen, not just to information held by government but to information held in the private sector;
f. Privacy and data-protection laws are also crucial, in order to protect the rights of individuals from abuse of their personal information and to give control to the information as to when and to now their personal information can be used.
g. Create web sites within government with information that will assist businesses, entrepreneurs and citizens, as a whole, seeking to engage in knowledge-based economic activity.
h. Work to bring about cultural change in institutions to adjust to the new economy emerging in the world.

Taking advantage of the knowledge revolution's potential hinges on effective economic incentives and institutions that promote and facilitate the redeployment of resources from less efficient to more efficient uses. This fundamental pillar of the knowledge economy provides the overall framework for directing the economy. Important elements of the economic and institutional regime include macroeconomic stability, competition, good regulatory policies, and legal rules and procedures conducive to entrepreneurship and risk taking. A key feature is the extent to which the legal system supports basic rules and property rights.

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