ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA

NEW INDICATORS FOR SCIENCE, TECHNOLOGY AND INNOVATION IN THE KNOWLEDGE-BASED SOCIETY

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Foreword

Reliable information on science, technology and innovation (STI) capabilities provide essential inputs for policy-making aimed at enhancing national competitiveness and productivity. In particular, sound implementation of STI policies must rest upon reliable information concerning the state of national science and technology (S and T) systems as well as regional and international trends likely to impact national competitiveness and productivity.

Traditional S and T indicators, emphasizing supply-side aspects, and inputs to national S and T "systems",* are collected and used by a relatively wide range of governmental and academic institutions in many developing countries, including member countries of the Economic and Social Commission for Western Asia (ESCWA). Innovation indicators, on the other hand, constitute novelties to almost all developing countries. While the traditional variety of S and T indicators currently used in the member countries are certainly of great value in policy and decision-making, they may only be of limited utility when dealing with the challenges and opportunities that these countries will need to tackle in an increasingly knowledge-based economy with intense global competition across all sectors.

Therefore, this study devotes special attention to recent efforts at extending S and T indicators to cover innovation activities, which are naturally more closely related to the implementation of S and T inputs in almost all production and services sectors in today's global economy. Such endeavours are already producing systems of indicators to characterize the state of national capabilities of STI. This must be viewed as prelude to instituting national systems of STI indicators that may be used in sound regional and international comparisons.

Concepts developed, particularly over the last half of the twentieth century have generally resulted in modelling activities undertaken at the national level with view to STI knowledge creation, dissemination, transfer and utilization as functions performed by specific components of national STI systems. This has given rise to a host of indicators dedicated to performance measurement on the basis of the engineering notions of the system. Chapter I of this study addresses STI systems and the increasing importance of STI indicators in benchmarking competitiveness and socio-economic development. Categories of indicators in common use are also discussed.

Chapter II is concerned with the traditional set of S and T indicators. Using the notion of a national "S and T system", a variety of input and output indicators are discussed. Input indicators provide tools for evaluating resources employed at a number of levels in a given country, typically including expenditure and manpower devoted to higher education, research and development and related areas of scientific and technological activities. On the other hand, output indicators, associated with traditional S and T systems, measure the extent of patenting and S and T publishing activity with which particular groups of S and T institutions and personnel are engaged.

Chapter III of this study examines indicators devoted to evaluating national innovative capacity. Innovation was previously conceived to be a linear progression from conception to production to commercialization, from the laboratory to the manufacturing plant to the market place. However, research during the latter part of the twentieth century has revealed that although this progression may be realized in broad outline, it does not sufficiently describe the complex and multi-dimensional processes involved in innovation. Innovation can occur in any sector of the economy, and at different levels, such as the product, process, or managerial levels. It is important not to exclude aspects of innovation that cannot easily be quantified, particularly those involving organizational or managerial changes. Chapter III discusses major efforts by the Organization for Economic Cooperation and Development (OECD) in conducting two Community Innovation Surveys, and publishing several reference materials on innovation data and methodologies for their collection.

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* For a detailed treatment of these notions see United Nations Economic and Social Commission for Western Asia (ESCWA). *Science and Technology Indicators – Basic concepts, definitions and prospects for development* (E/ESCWA/TECH/1997/6).

The notion of innovative capacity possessed by a given country has acquired enhanced importance within the context of the emerging knowledge-based economy. The part played by access to new information and communications technologies (ICTs) is the focus of attention in chapter IV of this study, which provides a brief discussion of indicators mostly related to physical ICT infrastructures, including the availability of telephone lines, personal computers, the Internet, and so on. However, for ICT capabilities to flourish, there must be an enabling environment in terms of policy and legislation, without which, countries will not be able to integrate their economies into the global knowledge-based economy. While this is certainly a challenge for both developed and developing countries, exciting new opportunities for economic prosperity will also arise due to the enabling nature found in ICTs.

Chapter V considers a set of composite indicators used by a number of international organizations in comparative surveys and studies touching upon STI capabilities. Some of the composite indicators in current use have prove quite useful in capturing the complex relationships linking STI knowledge creation and dissemination to sustainable development. Other multidimensional, composite indicators are generally designed so as to provide a view of STI capabilities and their implications for development from a particular angle. Composite indicators are not strictly confined to STI activities; they may also take into consideration socio-economic parameters, including illiteracy or number of years of schooling. Three types of composite indicators are discussed in this chapter. The first, the Technology Achievement Index (TAI), is used by the United Nations Development Programme (UNDP) in its 2001 Human Development Report. The TAI represents the capability of a country to create and diffuse technology, as well as how developed the human skills base is. The second and third indicators were devised by the European Union (EU), and are both related to the knowledge-based economy. Both indicators take into account factors pertaining to knowledge creation and diffusion.

The final part of the study provides a number of concluding remarks emphasizing essential elements in national strategies aimed at evolving viable capabilities in STI evaluation for the benefit of national STI–based development. Special note must be made here of the plans of ESCWA, in cooperation with concerned regional and international organizations, to act as hub for a regional network of national units or “observatories”, designed to monitor STI activity and act as focal points for establishment of national databases on STI indicators. ESCWA will also encourage the exchange of data, information and experiences on the implementation of relevant policies and strategies among its member countries. Training related to the collection and analysis of STI indicators and their incorporation in policy and strategy formulation will clearly be required. In this, as in other areas of activity crucial to sustainable development, ESCWA is quite keen to commit time and substantive resources.

Mervat Tallawy
Executive Secretary of ESCWA

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ABBREVIATIONS AND ACRONYMS

B2B	business to business
B2C	business to customer
BERD	business enterprise R and D expenditure
CIS	community innovation survey
CoP	community of practice
CORDIS	community research and development information service
DSL	digital subscriber line
EDGE	enhanced data rates for GSM evolution
EIU	economist intelligence unit
ERDP	ESCWA research and development portal
ESCWA	Economic and Social Commission for Western Asia
ESDU	Environment and Sustainable Development Unit
EU	European Union
FTE	full time equivalent
GCC	Gulf Cooperation Council
GDP	gross domestic product
GERD	gross domestic expenditure on R and D
GOVERD	government R and D expenditure
GPRS	general packet radio service
GSM	global system for mobile communications
HDI	human development index
HERD	higher education R and D expenditure
ICT	information and communications technology
IP	Internet protocol
ISDN	integrated services digital network
ISP	internet service provider
ITU	International Telecommunications Union
IX	Internet exchange
KM	knowledge management
MAE	metropolitan area exchanges
MEED	Middle East Economic Digest
NAP	network access point
NRI	Networked Readiness Index
NSI	National systems of innovation
NST	National System of Science and Technology
NTPI	the network of technology parks and technology incubators
OECD	Organization of Economic Cooperation and Development
PC	personal computer
PNPERD	private non-profit R and D expenditure
PSTN	public switched telephone network
R and D	Research and Development
S and T	science and technology
SBA	small business administration
SPRU	science policy research unit
STI	science, technology, and innovation
TAI	Technology Achievement Index
TLDN	top-level domain name
TPP	technological product and process
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme

ABBREVIATIONS AND ACRONYMS (*continued*)

UNESCO	United Nations Educational, Scientific and Cultural Organization
UNSD	United Nations Statistics Division
USPTO	United States Patents and Trademark office
WorLD	world links for development
WSIS	World Summit on the Information Society

Introduction

As a rule, indicators that evaluate performance in any area of human activity constitute essential tools for formulating and monitoring relevant policies. STI indicators are no exception to this rule. Given their special relationship to building and enhancing competitive capacity, STI indicators assume crucial importance in sustainable socio-economic development.

Indeed, increasing reliance on knowledge creation, dissemination, transfer and utilization, as bases for innovative and competitive activity, render national capabilities to use STI inputs in production and services more crucial.

In order to fully serve their purpose, STI indicators must enable comparisons between countries and institutions and over time. Collected data must be analysed and updated to serve sound policy-making and strategy orientations, reflected in new regulations, linkages and institutional arrangements. This calls for setting up national entities that specialize in the collection, comparison and analysis of STI indicators and the design of relevant policy interventions. This and other related issues will be reviewed in detail below.

Whereas recognizing the value of scientific and technological innovations as the basis for economic competitiveness, and through it sustainable development, is well established and widespread, this does not apply to the understanding of the complex processes involved in transforming this knowledge into commercially viable innovative inputs. As a result, innovations based on scientific and technological knowledge and their socio-economic impact are still dealt with implicitly by planners and decision makers.

On the other hand, it is widely acknowledged that astute "knowledge management" may give rise to considerable gains in innovative practices leading to enhanced competitiveness and productivity. Knowledge management will produce fruitful outcomes in manufacturing and services enterprises. Furthermore, gains due to knowledge management may not be confined to large or inherently "high-tech" enterprises. Indicators that characterize knowledge management capabilities are yet to be developed.[1]

This situation calls for research activity specifically designed to improve measures aimed at enhancing knowledge management and understanding how such management may contribute to innovative change based on scientific and technological inputs. Initiating such research activity and linking its outcomes to efforts aimed at charting the development of national STI capacity is an issue of extreme importance for the years ahead.

This study includes information, mostly numerical, for most of the indicators discussed. Such information is included for purely illustrative purposes and on the basis of available or readily accessible information, sometimes using Internet sources. Up-to-date data on STI indicators must be compiled with the support of regional and international organizations involved in building and improving competitive capabilities in the member countries on the basis of STI.

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[1] Economic and Social Commission for Western Asia (ESCWA), *Knowledge Management Methodology: an Empirical Approach in core sectors in ESCWA Member Countries* (E/ESCWA/ICTD/2003/9).

I. SCIENCE, TECHNOLOGY AND INNOVATION INDICATORS

Monitoring progress of national (STI) capabilities has acquired increasing importance over the past few decades. Enhanced awareness, during the latter half of the twentieth century, of the positive contributions made by scientific and technological knowledge, and its innovative utilization, to development, growth and international competitiveness was instrumental in promoting a variety of traditional S and T metrics, which are being continually reinforced by attempts at measuring national innovative capabilities.

Traditionally, societal support for S and T activity was measured using various methods, mostly based on contributions made by the public sector towards higher education and scientific research. During the 1960s and 1970s, interest focused on examining the performance of S and T systems and evaluating outputs produced by their activity.[2] This same period showed also much interest in publications, and perhaps to a lesser degree in patents. Greater interest was evident in the late 1970s and 1980s in indicators relating to S and T inputs that are embodied in new products and processes. Naturally, this required the development and application of more complex indicators. In more ways than one, traditional, and some non-traditional, S and T indicators relate to the notion of a national STI system.

A. SCIENCE, TECHNOLOGY AND INNOVATION: A HISTORICAL PERSPECTIVE

Throughout human history, progress in many walks of life has always been associated with knowledge and its effective utilization. Scientific and technological knowledge gained overwhelming importance throughout the past three centuries, culminating during the latter half of the twentieth century with a stream of discoveries that have transformed societies in innumerable ways. The main elements of national capacity in STI have traditionally been considered as residing in institutional—and sometimes individual—capacity to educate and train S and T manpower and to do research targeting new products and processes.

Even as recently as the 1950s and 1960s, innovation was conceived as simply based on a linear progression from the initial conception of an idea at the basic research level to its translation into an actual application. Branscomb named this linear conception of innovation the "pipeline" model.[3] According to this model, innovation is produced in a process that parallels the moving belt production model. To promote innovation, all that one needed to do is to minimize "bottlenecks" while maintaining a rich supply of inputs, namely Research and Development (R and D) funds and personnel.[4]

It is on the basis of this "research-in, technology-out" model that most of the S and T indicators currently existing pertain to either the input or the output side. Indicators used to measure innovation may be referred to as output indicators. Although this is not entirely incorrect, output indicators are insufficient to describe the complex and multidimensional aspects of the innovation process which depends on many factors beyond just R and D and technology namely effective knowledge sharing and interactivity, essentially based on communication capacity and related skills. These factors make it more difficult to measure innovation.

Experts recognize the need to analyse innovation as the product of a multitude of activities that proceed through an intricate web of linkages, as evident in the evolution of the definition of innovation itself. While the traditional definition of innovation stated that it is merely the application of technological knowledge and the creation of a new or improved product or service, its modern definition attempts to take into account many more aspects of the innovative process including legislative and regulatory ones. This

[2] Most of the work carried out in the Arab countries in this domain was, and still is, largely based on the Frascati Manual and the definitions it introduced to the multitude of entities that need to be dealt with in measuring, essentially national, performance in science and technology.

[3] Archibugi and Sitilli, "The direct measurement of innovation: the state of art", conference "innovation and enterprise creation: statistics and indicators", France, 23-24 November, 2000. Available at: http://www.cordis.lu/innovation-smes/src/statconf4.htm.

[4] N. Vonortas, "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

highlights the need to look into national systems of innovation and consider means whereby the innovative process is empowered and supported.

B. THE NATIONAL SCIENCE, TECHNOLOGY AND INNOVATION SYSTEM

The body of policies, regulations, institutional and infrastructural arrangements and activities concerned with the creation, acquisition, dissemination and utilization of scientific and technological knowledge, is generally referred to as the national STI system.

Analogous with the engineering definition of a "system", this term is generally used to describe the collection of heterogeneous entities involved in a mechanism. The national STI system is viewed as capable of producing, disseminating, adapting and implementing STI knowledge on the basis of input and output elements, such as human resources, funding and accumulated knowledge. Its operational mechanisms may include linkages both within the system, as well as alliances and cooperation with its surroundings.

An inherently social construct, the national STI system cannot be subjected to the rigorous analyses that are more successfully applicable in the physical or engineering sciences. Adopting the notion of a system in the evaluation of national STI activity helps elucidate characteristics of the components of the system, their functions, interactions and ultimately their impact on national development. When considering the particularities of a sector or discipline, the notion of an STI system may be more useful at a preliminary level of the analysis than for in-depth examination.

Expanding the notion of the STI system beyond the above-mentioned engineering concept to incorporate elements closer to biological, even social, may provide greater insight into concepts such as innovation and creativity. It might also improve capacity for considering the social implications of research and technological development efforts. Looking at STI systems in this light, as analogous in at least some respects to biological or social systems, might provide greater insight into crucial interactions that lead to the dissemination of scientific and technological knowledge, as well as monitor and improve their internal operations, in a manner familiar in biological and social systems that are endowed with forms of "intelligence", self-monitoring and evolution capabilities. Most of the industrialized countries owe their present status in science, technology and innovation to the fact that the national STI systems they have developed possess rudiments of "self-consciousness" and the ability for "effective self-assessment and control", both characteristic of intelligent biological or social systems.

The need to employ new, and even old, scientific and technological knowledge in innovative products and processes in manufacturing or service activities has given rise to a great deal of interest in the study of the innovation process. The following section highlights some of the main attributes of this process as a prelude to consideration of "innovation indicators" in chapter III.

C. THE INNOVATION PROCESS

Innovation relies on a variety of knowledge sources, including R and D activity, whether conducted by public sector institutions or enterprises, as well as technology acquisition through a variety of modalities. In the case of enterprises, innovation may rely on input by clients, consultancy firms, educational and research institutions, and other generally available information.[5]

Innovation may occur at different levels ranging from the product to the process or managerial levels, whereby product innovation involves the creation of new products and services; and process innovation means improved and more efficient methods in an industrial process or the investment in new machinery.

[5] These include patent disclosures, conferences, meetings and journals.

Modifications in organizational and management structure are often as crucial as process and product innovations,[6] as they can create competitive edge and lead to productivity gains. Thus, implementation of advanced management techniques, new corporate strategies orientations or novel means for the knowledge sharing and dissemination within a firm may be defined as organizational innovations, but only when it brings about measurable improvements in productivity, product quality or sales.

The development and diffusion of new technologies plays a central role in improved productivity and competitiveness. While the global economy is being reshaped by new ICTs and by radical technological changes in a number of other disciplines in S and T, understanding the processes that lead to innovations and to their dissemination, both within and across sectors, is still deficient. Consequently, the impact of technological changes is still dealt with implicitly by planners and decision makers and is not normally reflected in reporting on total factor productivity and in output growth rates.

Knowledge flows are closely linked to the innovation process. OECD describes four main types of knowledge or information flows:[7]

(a) Interaction between enterprises, namely, through joint research activities;

(b) Joint research activities between enterprises, universities, and public research institutions, including co-patenting and co-publishing;

(c) Knowledge and technology diffusion to enterprises, through the adoption of new machinery and equipment;

(d) Mobility of personnel carrying tacit knowledge, especially within and between the public and private sectors.

Several approaches have been developed for analysing National Systems of Innovation (NSIs). Firm-level surveys are the most used for collecting information on innovative activity with reference to particular industrial sectors and countries. Another common approach is to study interactions between particular firm groups and sectors, thus revealing the patterns of knowledge flows between clusters. Box 1 briefly discusses the concept of knowledge management, a crucial element in innovation.

Success in refining the analysis of innovation is essential in improving understanding of the link between technological change and economic performance. For ESCWA member countries, such success will help in formulating strategies for the collection and analysis of information on progress made in acquiring new scientific and technological knowledge and the promotion of national capacity building in innovation.

ESCWA member countries suffer many limitations and inadequacies in related institutional arrangements, infrastructure, and policy regimes seriously hindering their ability to innovate in many directions. This is expected to affect their performance in the emerging global knowledge-based economy.[8] Policy makers must consider socio-economic particularities and carefully map interactions of potential innovative activity within their countries.

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[6] Feasibility study for the creation of an International Network for Small and Medium Enterprises "INSME Project Plan", Italy, 23 January 2002. Available at: http://www.insme.info.

[7] Organization for Economic Cooperation and Development (OECD), "National Innovation Systems", Paris, OECD, 1997. Available at: http://www.oecd.org/pdf/M000014000/M00014682.pdf.

[8] ESCWA, *Science and Technology Policies in the Twenty-First Century*, New York, 1999 (E/ESCWA/TECH/1999/4).

Box 1. Knowledge Management[a/]

The concept of Knowledge Management (KM) describes knowledge as an asset, one that must be managed similar to capital and other resources in the enterprise, or institution for that matter. KM parameters include:

(a) Performance measurement, essentially the ability of the firm or institution in question to measure the quality and effectiveness of its innovation practices;

(b) Knowledge creation, referring to the allocation of various enterprise resources for the development of new products and/or processes.

These two parameters provide implications for new indicators that have been found to correlate almost directly with innovation capabilities. Other KM issues being evaluated for their relationship with innovation address the following:

(a) Innovation leadership;
(b) Competitive intelligence, or the ability to monitor current and potential competitors;
(c) Strategic alliances of skills needed to monitor, make and manage these alliances.

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a/ ESCWA, *Knowledge Management Methodology: an Empirical Approach in Core Sectors in ESCWA Member Countries* (E/ESCWA/ICTD/2003/9).

D. CATEGORIES OF STI INDICATORS

STI indicators may be grouped into many categories or classes and according to a variety of conceptual frameworks. An important class of indicators, for instance, addresses STI human resources and related development activities, such as the number of researchers, education, and training activities undertaken to enhance their effectiveness. Another may be designed to appraise R and D activity, including national expenditure on R and D, output produced by national R and D institutions and the effectiveness of linkages between such institutions and others concerned with the utilization of R and D output.

Indicators may also be classified in terms reflecting their position within the national STI system, as indicators of input, output or processes and linkages. An example of input indicators would include a number of researchers and financial expenditure on R and D. Indicators of STI output include, for instance, the number of patents and published papers. Indicators related to processes and linkages might address joint research activity, joint publications and research contracts.

Indicators that address the impact of STI activity on economic performance might include revenues generated by high technology enterprises or the export of high technology products in comparison with total exports.

Another possible method of classifying STI indicators can rely on the nature of national activities undertaken, particularly relating to whether that activity targets the creation, dissemination, transfer or utilization of STI knowledge. This classification may be especially suited in the present state of STI development in ESCWA member countries. This state is essentially characterized by considerable demarcation of the areas of activities mentioned above, at the level of institutions and resources reflected in the present study.

New ICTs have been instrumental in introducing a multitude of changes in the manner with which countries and institutions innovate to achieve a competitive edge. Therefore, indicators that describe national and enterprise performance in ICTs, both as users and developers, acquire special importance.

While innovations may occur in any sector of the economy, those that take place at the enterprise level have been credited with more direct benefits for national growth and competitiveness. Some possible innovation indicators include the proportion of "innovating" firms, as opposed to the "non-innovating" ones,

the impact of or the percentage of sales derived from innovative products, as well as other indicators relevant to the measurement of innovation, such as resources devoted to R and D.

E. CONCLUDING REMARKS

The concept of a national system of science and technology (NSTs) and of a national system of innovation (NSI) emphasizes interactions among actors involved in the creation, dissemination and utilization of scientific and technological knowledge and innovative activity. In effect, it is these interactions that eventually transform the collection of input elements into innovative change. The importance of understanding and promoting these crucial interactions in policy making cannot be overemphasized in devising modalities to enhance innovative performance.

Despite merits that can be attributed to considering NSTs and NSIs separately, the present study is in favour of opting for the more comprehensive national STI system as basis for measuring progress in capabilities of STI. Given that the present study addresses indicators belonging to both "systems" in separate chapters is essentially due to the fact that innovation indicators are still at an embryonic stage of development worldwide, more so in ESCWA member countries.

An essential characteristic of a successful national STI is the ability to improve its own performance through internal institutional arrangements and implementation of strategies that promote information flows among participating actors. Examining interactions that allow this "auto-remediation" or "self-improvement" in innovative activity provides insight into the success or inadequacy of an innovation system. At any rate, technical collaboration, technology diffusion and personnel mobility, are known to contribute to enhanced innovative capacity of enterprises in terms of products, patents and productivity.[9]

Whatever system is used in classifying STI activity, it must allow for considerable overlap among various classes within a given system of indicators. Thus, the class of indicators that addresses R and D activity, shares a number of items, targeting human resource development endeavours. Similarly, at least some of the indicators that evaluate technology transfer across boundaries are also of considerable significance in activities aimed at the implementation of STI knowledge.

While innovations can occur in any sector of the economy, those that take place at the enterprise level have been credited with enormous benefits for national economic growth. National plans aimed at the creation of STI capabilities will need to allocate a great deal of attention to the evaluation of innovation at the level of the business enterprise and the level of individual segments and sectors. Activities related to enterprise creation, incubation and promotion undertaken in universities and research centres of a country, must receive adequate attention in initiatives design to improve national STI monitoring capabilities.

This study aims at linking categories of STI indicators in order to enable analyses of a given STI system, in addition to help characterize and monitor the performance of its components.

[9] OECD, "National Innovation Systems", Paris, OECD, 1997. Available at: http://www.oecd.org/pdf/M000014000/M00014682.pdf.

II. SCIENCE AND TECHNOLOGY INDICATORS

Analysing a given S and T system helps identify its components. In this regard, three main constituents may be listed, including inputs, processes and outputs. Traditional S and T indicators have mainly been concerned with the measurement of input and output. Thus, it is customary to measure the quantity of output of the system generated by a given S and T system, as it relates to the quality of input received. Input and process indicators serve as reference points since they provide insight into areas directly influenced by policy. Meanwhile, output indicators can be associated with the quality of the system. More recently, inputs and outputs of the system are being studied from a qualitative point of view. With this in mind, S and T indicators may be grouped within categories on the basis of their intrinsic nature, being quantitative or qualitative, or according to the phases of the process they address, specifically, input, output and processes.

S and T systems are often dissected into sub-systems in accordance with their main functions, namely, higher or general education, R and D, technology transfer or acquisition. The variety of S and T indicator categories, developed and utilized by world bodies, such as UNESCO and OECD, include parameters that measure the performance of national S and T systems in such sub-systems. Naturally, the higher education and R and D components play an important role as creators of both input and output within a comprehensive national S and T system.

A. RESEARCH AND DEVELOPMENT INDICATORS

Innovation activity is directly related to national R and D activity, the general tendency in the assessment of which has been to emphasize quantitative input indicators over output indicators. The complexity of estimating R and D output has incited wider use of indicators such as expenditure on R and D, number of R and D personnel, and the number of R and D projects in a particular area.[10] Related indicators have also been assembled on the basis of the former indicators, namely, number of researchers per project in a particular area, annual expenditure per researcher and per project, and so on. Annex I presents several commonly used R and D indicators, while annex III presents further indicators as well as selected data for the Arab region.

Indicators designed to provide information on a country's support for, and performance in R and D often address contributions by five "sectors", related to the gross national expenditure on R and D:

(a) Business Enterprise R and D expenditure (BERD): Accounts for contributions to R and D activity made by firms, organizations and institutes that primarily produce goods and services[11] for sale to the general public, as well as the non-profit private institutions that service them. Contributions to R and D by public sector enterprises are also included within this category;

(b) Government R and D expenditure (GOVERD): Incorporates R and D expenditure by agencies, offices, and other entities that offer public goods and services,[12] as well as those that oversee governmental, economic, and social policies of the country or community in question. This indicator also includes expenditure by non-profit institutions funded and directed by the government;

(c) Higher Education R and D expenditure (HERD): Accounts for R and D expenditure by higher education institutions, including universities and colleges, irrespective of their source of funding, degree of dependence on public policies or legal profile. This is also inclusive of expenditure by research centres, experimental stations and clinics that operate under the wing of higher education institutions or are affiliated with such institutions;

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[10] One of the limitations of the data collected for estimating resources devoted to R and D is the fact that being an input, it does not measure technical change, and falls short of including factors such as learning-by-doing.

[11] Excluding higher education.

[12] Idem.

(d) Private Non-profit R and D Expenditure (PNPERD): Includes expenditure by non-profit institutions that serve the public sector, as well as those by individual donors to R and D activity;

(e) Extra-national contributions: Refers to contributions by organizations and individuals resident abroad.[13] This would include international organizations and any physical assets and activities they may deploy within national borders.

Clearly, it may be possible to develop intricate indicator systems and conduct more detailed analyses with regards to R and D contributions by the business and governmental sectors if additional data were available, including:[14]

(a) Type of research expenditure, whether it is basic, applied, or merely involves development based on research already concluded;

(b) Area of scientific or technological activity in question, namely, life sciences, natural sciences, mathematics, computer sciences, environmental sciences, and so on;

(c) More detailed information about the nature of funding source.

Indicators on R and D expenditure have been used extensively for intercountry benchmarking, as well as for charting progress, or lack of it, in R and D activity across time and in comparing R and D support being provided to various sectors and organizations within the same country.

R and D activity is used in determining the "technological intensity"[15] at the enterprise or sectoral levels, which in its turn, may be used to indicate productivity growth and international competitiveness. Technological intensity varies from one industry to another, and countries are distinguished in reference to the level of technology adopted by prevalent industrial activity, namely as to whether they host high-tech, medium-tech or low-tech industries. Despite its apparent simplicity, this classification suffers some ambiguity. For instance, the definition of a high-tech industry may not clearly distinguish whether the country in question is engaged in extensive imports of the high technology it uses, implying effective technology transfer and knowledge-intensive modalities, or is in fact producing the high technology inputs it uses itself.

Three indicators of technological intensity are used in the classification of industries, each featuring characteristics of technology production and technology consumption. These include:

(a) R and D expenditure over value added;

(b) R and D expenditure over production;

(c) R and D expenditure plus embodied technology in the utilized intermediate goods and investment goods over production.

Clearly, the use of these indicators would require detailed and standardized information on the economic performance at the enterprise and national levels.

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[13] With the exception of the cars, ships, airplanes and space satellites that are operated by domestic organizations and the experimental locations of these organizations. Vonortas, N. "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

[14] N. Vonortas, "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

[15] In 1995, OECD put forward a broadly acceptable methodology based on efforts that take into account the difficulties.

In relation to R and D personnel, the Frascati Manual includes all individuals directly employed in R and D and those that provide direct services such as directors, managers and other R and D division employees. Several categories of research personnel may be distinguished (see box 2). Box 3 presents a brief analysis of two R and D indicators for the Arab countries, number of personnel involved in R and D activities, and the number of R and D units and their distribution by area of research.

Box 2. Research personnel as defined in the Frascati Manual

The Frascati Manual defines the following categories of research personnel:

(a) Researchers (scientists and engineers), including professionals whose primary occupation is to conceive and apply new knowledge, products, production processes, methods and systems, and the management of research projects;

(b) Technical personnel, including individuals whose primary occupation requires technical knowledge and experience in one or more fields of engineering or other science. They work in R and D and carry out scientific or technical tasks based on the application of ideas and methods, usually under the supervision of the researchers. Other similar personnel carry out case specific R and D tasks under the supervision of researchers in social sciences and the humanities;

(c) Support personnel, including skilled and unskilled craftsmen, secretaries and other personnel working in R and D projects.

Both the Frascati Manual and the UNESCO Manual distinguish between full-time and part-time work, allowing aggregation to “full-time equivalent” numbers:

(a) Full-time scientific and technical personnel are individuals spending at least 90 per cent of their working time on specific scientific and technological project;

(b) Part-time scientific and technical personnel are individuals who spend only part of their working time on a specific scientific and technological project.

Source: Organization for Economic Cooperation and Development (OECD), Frascati Manual “The Measurement of Scientific Activities: Proposed Standard Practice for Surveys on Research and Experimental Development”. Paris, OECD, 2002.

Box 3. Research and Development in the Arab countries

One of the main obstacles faced by policy makers in comparing statistics between the Arab countries is the lack of a set of regularly produced and standardized indicators. The latest disaggregated data available on Research and Development for the Arab countries dates back to 1996, from a report produced jointly by ESCWA and the UNESCO Cairo Office in 1998. The appraisal of the following indicators is made with the purpose of highlighting a number of relevant issues of regional as well as national dimensions, but it is important to bear in mind the inadequacy of available data.

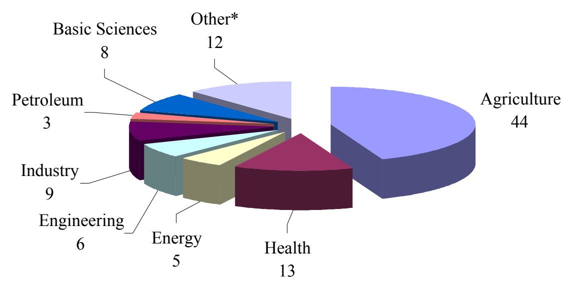
Full Time Equivalent (FTE) Researchers: The distribution in 1996 of full-time researchers in Arab countries shows that the majority, around 44 per cent, converges on agricultural research, mainly due to the fact that most Arab countries have an important agricultural economy. Egypt, for instance, allocated almost half of its FTE workforce in this field, and concentrated on FTE researchers in the region, a total of 10,744, or 56 per cent. There are only three Arab countries whose main area of research concentration is different, namely Bahrain, Jordan and Qatar, with a focus on economics, industry and education, respectively. Figure 1 shows the number of FTE researchers in 1999 in the Arab countries, distributed across specific areas of R and D. It is worth noting that research on petroleum-related topics, being the main source of income for many Arab countries, hosts a relatively low number of researchers. In 1996, only 6 to 8 per cent of FTE researchers in Kuwait, Oman, and Saudi Arabia were dedicated to petroleum, and 11 to 15 per cent dedicated their research to energy. The United Arab Emirates dedicated 64 per cent of its FTE researchers to agriculture, while Jordan, with around 24 per cent, possessed the highest fraction of researchers in the region dedicated to industry. Engineering researchers in 1996 were most prevalent in the Syrian Arab Republic, at 32 per cent of total researchers. Meanwhile, Lebanon and Qatar had 22 and 24 per cent of their FTE researchers dedicated to the basic sciences. Annex table 15 presents further information on the number and percentage of FTE researchers and their distribution for each of the Arab countries in 1996, whereas annex table 17 presents some more specific R and D figures for ESCWA member countries in particular.

Box 3 (*continued*)

Distribution of R and D units by R and D area: In 1996, there were 322 R and D units in the Arab countries, 55 of which operated in the agriculture sector. Once again, Egypt led the Arab countries with a total of 64 R and D units, mostly dedicated to health, industry and agriculture. It is noteworthy that a presumably important area for R and D efforts, namely water, attracted the interests of a relatively small number of institutions, comprising 17 units. Egypt and Saudi Arabia account for 35 per cent of all R and D units of the Arab world (see annex table 16).

R and D expenditure: The R and D expenditure in the majority of ESCWA member countries were in the range of $3 million to $70 million (see table 1). The obvious exceptions were Egypt and Saudi Arabia that had R and D expenditure values of $227.5 million and $196.1 million, respectively. The R and D expenditure per FTE researcher is a more valuable indicator that allows suitable comparisons between countries. Although the total R and D expenditure in Bahrain was the lowest among ESCWA member countries, the expenditure per FTE researcher was $43,500, almost double that of Egypt at $21,200. The highest value of R and D expenditure per FTE researcher was that of Saudi Arabia with a value of $231,800. Annex table 15 presents additional information on the number of FTE researchers and support personnel.

Figure 1. Full-time equivalent (FTE) researchers in the Arab countries by area of R and D, 1999



Source: Adapted from ESCWA-UNESCO, *Research and Development Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/3).

* "Other" combines research management, economics, and education.

TABLE 1. R AND D EXPENDITURE IN ESCWA MEMBER COUNTRIES (1996)

	R and D expenditure (millions of US$)	R and D expenditure per FTE researcher (thousands of US$)
Bahrain	3.7	43.5
Egypt	227.5	21.2
Iraq	27.6	19.8
Jordan	20.6	51.4
Kuwait	67.1	152.5
Lebanon	7.5	36.3
Oman	10.8	131.2
Palestine	..	..
Qatar	5.5	160.6
Saudi Arabia	196.1	231.8
Syrian Arab Republic	24.2	67.9
United Arab Emirates	10.9	101.8
Yemen	10.3	38.1
ESCWA member countries	611.7	40.9

Source: Adapted from ESCWA-UNESCO, *Research and Development Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/3).

Common R and D output indicators include the numbers of publications and patents produced. See section on "Intellectual property indicators" below. Indicators on publications and patents issued per capita of the population in general and relative to R and D personnel population are customarily used in assessing national and institutional "research intensity".

From a quantitative point of view, R and D output can be measured through an assessment of the knowledge embodied in published scientific discoveries and technological innovations, as well as from sources of information that detail published research reports and patents. However, it is more difficult to measure the creation of knowledge that stems from R and D activities. It is essential to carry out exhaustive surveys of the literature, involving experts in the field, to establish if the discovery in question is a genuine discovery or simply a restatement or reinterpretation of an earlier one.

Determining the importance or relevance of R and D activity to national development has to be measured by analysing research publications. One commonly used indicator is the frequency with which a particular publication is cited in subsequent publications within the same or related fields. A number of bibliographic databases have been constructed to document research articles in refereed international journals. The share of a given nation in world publications is generally regarded as a useful indicator of the abilities of its researchers, as well as a measure of future potential for training and further technical development. While the share of world publication outputs is a quantitative indicator, the fact that it derives from a large body of refereed material renders it a useful indicator of research quality as well.

B. BIBLIOMETRICS

Statistical analysis of scientific publications may be conducted to study the extent and distribution of scientific output in a given field as well as the contributions of specific institutions or individuals. Bibliometric indicators generally focus on the output of research activity undertaken primarily in universities and public research institutes, and address both the quantity and the quality of such activity. Same as with other indicators, they are significant only in a comparative sense.

One of the basic weaknesses of using bibliometrics as an indicator is that it is based on the premise that the ultimate objective of scientific effort is knowledge production and that this is reflected in relevant literature. Despite their extensive use for evaluating scientific output, bibliometric indicators possess some additional shortcomings:[16]

(a) Different scientific fields publish and cite prior work differently. Variations are also present between countries;

(b) Language biases may arise due to working with selected journals and periodicals. This is especially true in the developing countries, particularly those in which the working language of instruction and scientific communication is not English. Naturally, the Arab countries fall in this category;

(c) Certain valuable scientific output that has become part of the "obvious" may no longer be cited;

(d) Extended periods of time often elapse between reporting a given result and adequate recognition of its value;

(e) Principal periodicals refer only to productive experimental or laboratory work, leaving out innovations in important fields including computation or software development.

Bibliometric indicators usually use a full-counting scheme of publications grouped by countries or regions. Otherwise, they may consider the distribution of periodicals across different scientific fields. It is

[16] N. Vonortas, "Science, Technology and Innovation Indicators", George Washington University, USA, 2002.

also possible to combine several citation impact indicators into more complex indices, which could be accomplished by the following techniques:

(a) Relative specialization index: indicating the country's share of global publications in specific scientific fields relative to its share across all fields;

(b) Co-authorship: determining the link between different geographical regions by the association of several authors on the same publication;

(c) Scientific productivity: measuring the productivity of individual organizations;

(d) Citation-based indicators: quantifying the citations or references made to an article from other articles over a certain period of time.

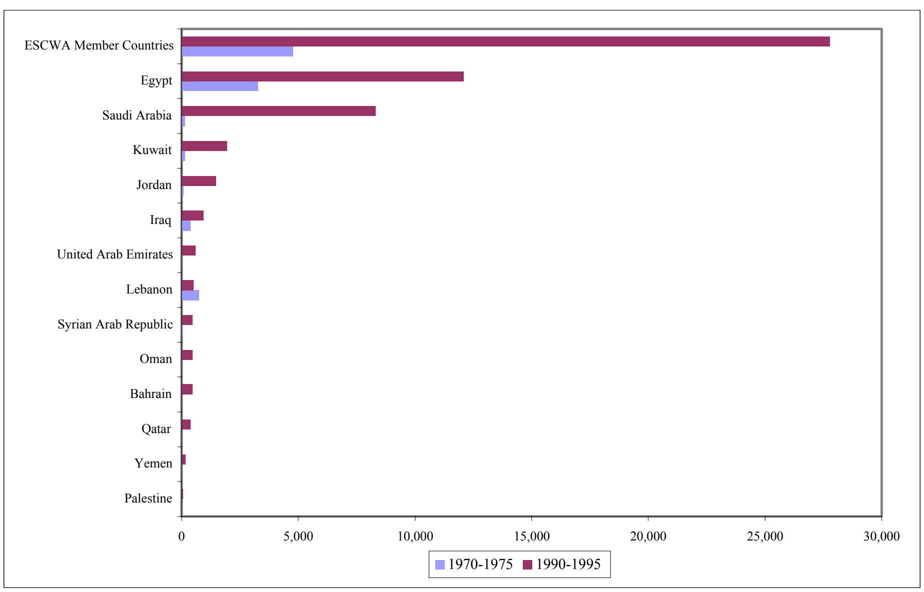
Box 4 presents statistics on papers published in ESCWA member countries.

Box 4. Science and technology papers published in ESCWA member countries

The number of science and technology papers published in refereed international journals have increased in the last twenty years from a total 5,865 in the period ranging from 1970 to 1975, to 34,594 from 1990 to 1995. Egypt and Saudi Arabia are the most prolific in absolute terms; together they produced almost 74 per cent of all papers published in the Arab region between 1990 and 1995. Lebanon is the only country in the region whose publishing output decreased from 743 during 1970-1975, to 500 during 1990-1995 (see figure 2). However, the number of citations received by these published articles is very small. The latest figures published by the Arab Human Development Report 2002 indicate that only four papers from the region are cited more than 40 times, almost negligible compared to the thousands of articles from the United States cited the same number of times. Figure 2 presents the number of refereed published papers for all of the Arab countries.

Source: United Nations Development Programme (UNDP), *Arab Human Development Report 2002*: *Creating Opportunities for Future Generations*. Jordan, 2002.

Figure 2. Number of papers published in ESCWA member countries



Source: United Nations Development Programme (UNDP), *Arab Human Development Report 2002*: *Creating Opportunities for Future Generations*. Jordan, 2002.

C. INTELLECTUAL PROPERTY INDICATORS

Organizations and individuals involved in innovative activity apply for patents, copyrights and trademarks in order to protect inventions from commercial exploitation,[17] and benefit from their economic gain.

Patenting is a primary tool to protect the rights of a firm or individual to receive royalties on production and services activities based on an innovative concept. Patent output generated by a national S and T system provides an overall indicator of technological standing, and is utilized to assess success and specialization relative to other countries. The number of patents granted in a given sector to a particular institution, or to researchers in a given discipline, is useful as an indicator of institutional and individual contributions to innovation in that sector or discipline. The number of patents awarded for applications in a given area indicates to some extent the intensity of actual innovation within that area. Shortcomings of the use of patents as an indicator of R and D output include the fact that not all innovations necessarily correspond to a certain patent, and that some patents that do correspond to inventions offer little economic value.

Other limitations from resorting to patents as a measure of STI output include the following:

(a) Variations in patent systems across countries;

(b) Discrepancies as a result of differing tendencies to patent between sectors and organizations;

(c) Difficulties in assigning patents to a specific country or geographical location as some firms tend to patent centrally, applying from headquarters irrespective of the geographical location of the invention;

(d) Most patents never reach commercialization, and as such their true contribution to competitiveness and productivity is not achieved;

(e) Some worthwhile inventions, primarily of cultural nature, but also including software items and certain biotechnology/genomic products such as new forms of life, are not protected with patents.

In fact, the Oslo Manual states that patent data are not indicators of innovation outputs, but rather of invention, and highlights the need for examining questions about patenting activity so as to gain a deeper understanding of the innovation process.[18] Patent data is used quite extensively due to its perceived simplicity. More detailed analysis of patent information, often made by economic and business analysts is constructed almost exclusively on the basis of information provided on the first page of a patent document, including:

(a) Full title of the invention;
(b) Year of application or award;
(c) Name(s) and the location(s) of individuals and/or organizations claiming ownership;
(d) List of claims made by the patent;
(e) Technological field(s) of the invention;
(f) List of prior patents and scientific publications cited in the patent application;
(g) Technological field(s) of all cited patents and the scientific field(s) of all cited publications;
(h) Brief description of the content of the specific invention.

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[17] Other mechanisms for protecting intellectual property include methods such as secrecy, first-mover, early start on the technology learning curve.

[18] OECD, Oslo Manual, "The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data". Paris, OECD, 1997.

Based on data collected from patent offices, it is possible to extract several variables pointing to the extent and level of patenting activity:

(a) Summarized description of the invention;

(b) Various patent counts according to country, industry or technological field, time period, assignee type;[19]

(c) Geographical distribution of assignees;

(d) Percentage shares of patent renewals;

(e) Number and type of contested patents.

These variables are relatively straightforward and provide valuable information that can primarily be used in economic, business, and policy analyses, which may be further enriched by incorporating economic and social variables leading to indicators that address the following factors:[20]

(a) Productivity of companies due to the impact of technology. Patents have been extensively studied in analysing company economic growth;

(b) Determinants of technological advance relating to the production/import of new technology;

(c) Spillovers/knowledge flows implying the extent of technological exchange and knowledge accumulation;

(d) Technology foresight inferring the evolution of technological advance, and the impact of certain technologies on productivity.

Box 5 gives an account of the status of selected countries in patenting innovation.

Box 5. Patenting activity in selected countries

Figure 3 presents the total number of patents registered with the United States Patents and Trademark Office (USPTO) for selected ESCWA member countries as well as other selected countries in the world. The need for a logarithmic scale on the graph alone highlights the deficiency of the region in patenting activity. In the period ranging from 1992 to 2001, ESCWA member countries have registered between one and 42 patents, with the exception of Saudi Arabia, which has been granted a total of 117 patents. In fact, summing together the number of patents granted to each ESCWA member country between 1992 and 2001 barely amounts to 4 per cent of the total number of patents granted to Israel. Nevertheless, patenting has steadily been on the rise in the region as a whole. In 1992, 15 patents were granted to the ESCWA region, whereas the number grew to 36 in 2001.

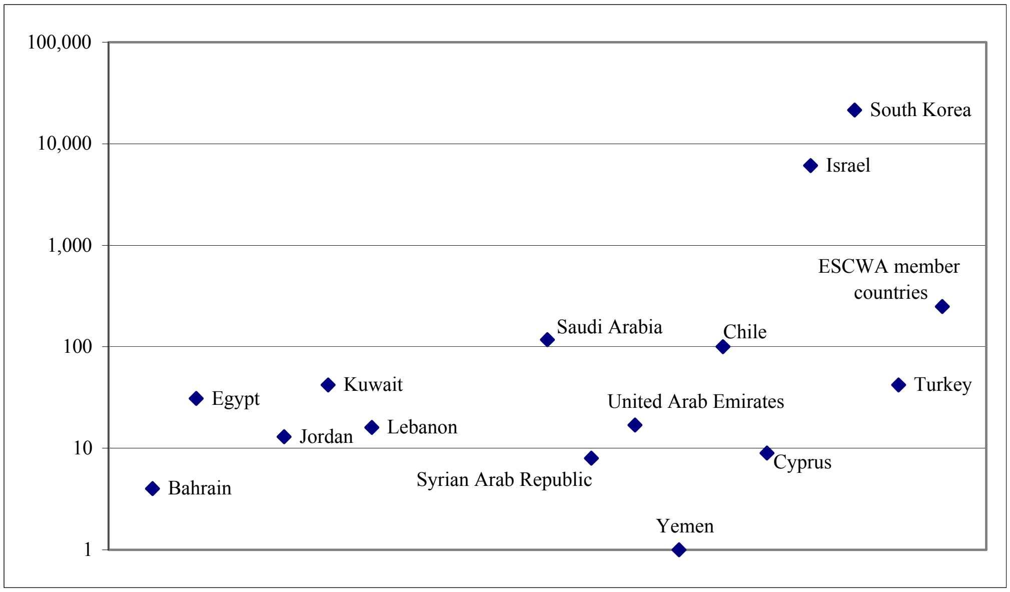
D. HIGHER EDUCATION INDICATORS

A set of widely used S and T input indicators addresses the performance of higher education institutions and their contribution to the accumulation of skilled human resources and intellectual capital available to a given country. Gender segregated statistics are characterizing outputs of these institutions, namely graduates of universities and technical/professional schools. Data included in these indicators covers the field of specialization, degree or diploma, year of graduation, geographic location of the educational institution, and nationality of the graduate. Factors including enrolment in the different levels of the national system of higher education are also addressed.

[19] Could be an individual, a company, university, and so on.

[20] N. Vonortas, "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

Figure 3. Cumulative number of patents granted to selected countries by the USPTO, 1992-2001



Source: Adapted from the United States Patents and Trademark Office web site, available at: http://www.uspto.gov.

Note: A logarithmic scale has been used due to disparities between the patent counts.

Analysing information on higher education and vocational training is often carried out with regard to both input and output elements. Indicators less frequently used are those that refer to the quality of higher education, the assessment of which necessitates a broad perspective of life-long learning, rather than restrict focus to the current labour market.

Input indicators include expenditure on higher education, the number of students enrolled in the various stages and areas of specialization, the ratio of students to professorial and assistant staff, spending on higher education in relation to gross domestic product and per student, the amount and type of equipment, science facilities, and number of computers available in institutions, and so on.

With regard to knowledge or information inputs, indicators may include the availability, quality and usage rates of existing links to the Internet, international databases and electronic libraries and information resource centres.

Output indicators in higher education frequently refer to the number of graduates in different areas of specialization, whereas the quality of the higher education system is measured by course completion rates across disciplines and areas of specialization, and the success rates in acquiring jobs at the end of the higher education courses, the latter being both an indicator of the prevailing general economic conditions, and of the supply and demand of specialized professionals of a particular economy. Annex table 2 presents a comprehensive list of higher education indicators.

Attempts at engendering greater interaction between higher educational and institutions undertaking socio-economic activities have taken concrete shape in many industrialized and industrializing countries in a variety of university-society linkages. University-industry links, enterprise incubation schemes, technology and research parks are but a few such forms. It is therefore only natural that the existence and performance of such links are included in more detailed analysis of higher education.

Box 6. Higher education in ESCWA member countries

During the 1990s, Arab countries witnessed a high growth in the number of universities. Unfortunately, not all statistics on higher education systems in the Arab countries are available after 1996, further illustrating the obvious inadequacies in statistical resources in the region. The total number of universities in the Arab region increased by 50 per cent, from 117 in 1990 to 175 in 1996. The number of technical institutes increased by 35 per cent over the same 6-year period, from 396 in 1990 to 539 in 1996. It is noteworthy that the number of non-governmental universities increased seven-fold between 1990 and 1996.

Higher education infrastructure: Figure 4 shows the total number of universities in ESCWA member countries in 1996. ESCWA region alone shows an almost 60 per cent increase in the number of universities from 1990 to 1996, with significant growth in Yemen, which established 13 new universities in the 6-year period. In the distribution of colleges within Arab universities, the Syrian Arab Republic holds the highest percentage of S and T colleges as opposed to those dedicated to Humanities and Social Sciences (H and SS). In fact, over 70 per cent of the Syrian Arab Republic's 45 colleges in 1996 were S and T colleges, whereas in Yemen 65 per cent of 91 colleges in 1996 were H and SS colleges. Other ESCWA member countries show a more even distribution between the S and T, and H and SS colleges (see table 2). The most recent statistics on the number of students and staff in higher education in ESCWA member countries do not all belong to the same year as shown in table 3. For comparison purposes, the student/staff ratio is of more significance than the actual numbers. Oman had the lowest student-to-staff ratio in 2001 at a value of 10. The highest student-to-staff ratio was in Yemen at 43 students to one staff member in the year 2000.

Higher education expenditure: Although a good higher education system is characterized by a number of variables, one of the most significant input factors is expenditure, usually reported per capita or as a percentage of the country's GDP. Total higher education expenditure in the Arab countries amounted to US$ 6,976.7 millions in 1996, of which ESCWA member countries accounted for a considerable 80 per cent.

Figure 5 illustrates the higher education expenditure per capita. Clearly, Kuwait far exceeded the average expenditure in the ESCWA region in 1996, and it is interesting to note that Kuwait had only one university that year. On the other extreme, Yemen, with 15 universities in 1996, spent only US$ 3.9 per capita on higher education that year. Table 4 shows higher education expenditure in the Arab countries as a percentage of GDP for 1996. As a whole, Arab countries allocated an average of 1.25 per cent of their GDP to higher education expenditure in 1996.[a/] Of ESCWA member countries, Jordan allocated the highest fraction at 3.1 per cent, while the United Arab Emirates allocated a mere 0.3 per cent in 1996. However, a majority of ESCWA member countries allocate a "medium" to "high" portion of their GDPs to higher education expenditure. Higher education expenditure per student is another useful indicator in the assessment of a country's investment in higher education. The values for ESCWA member countries in 1996 are shown in table 5. Saudi Arabia exceeded all other ESCWA member countries in the amount assigned to higher education per student with a value slightly lower than $10,000. Egypt, on the other hand, had a relatively low amount of higher education expenditure per student at about $1,120 although it had the highest number of universities in 1996. Moreover, the higher education expenditure per student in Yemen had the lowest value at about $500 indicating a low investment in higher education.

Student enrolment and graduates: Student enrolment in the Arab region, particularly at the Bachelor level, has been on the rise over the last decade. Masters and Ph.D. students have also increased in number, though slightly—partly because not all universities in the region possess the necessary capabilities, in terms of qualified faculty members, course material and equipment.

Table 6 presents the number of university students and graduates in ESCWA member countries in 1996. During that year, around 95 per cent of the students in the entire ESCWA region were enrolled for a Bachelor degree, 4 per cent for a Masters degree, and 2 per cent for a Ph.D.

Across the Arab region as a whole, 29 per cent of Bachelor students, 49 per cent of Masters students, and 64 per cent of Ph.D. students were enrolled in S and T fields in 1996.[a/] Female enrolment has increased significantly since 1991, especially at the Bachelor level. In 1996, females formed 41 per cent of the total university enrolment. However, there has been an apparent decrease in females in S and T fields at the Bachelor level between 1991 and 1996.[a/] More recent numbers of higher education students and graduates are presented in annex tables 18 and 19.

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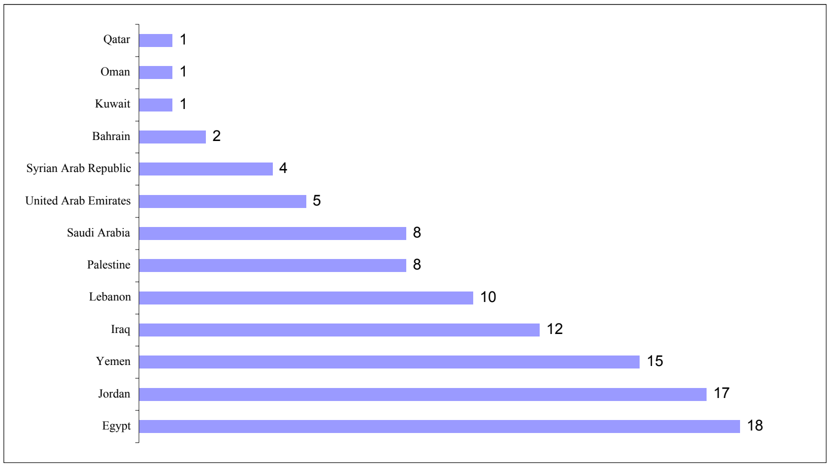
a/ ESCWA-UNESCO, *Higher Education Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/1/Rev.1).

Figure 4. Number of universities in ESCWA member countries, 1996



Source: Adapted from ESCWA-UNESCO, *Higher Education Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/1/Rev.1).

TABLE 2. DISTRIBUTION OF UNIVERSITY COLLEGES IN ESCWA MEMBER COUNTRIES, 1996

	Number of S and T colleges	Number of H and SS colleges	Total number of colleges
Bahrain	4	3	7
Egypt	106	120	226
Iraq	42	44	86
Jordan	50	51	101
Kuwait	4	5	9
Lebanon	32	34	66
Oman	4	2	6
Palestine	18	24	42
Qatar	2	4	6
Saudi Arabia	33	47	80
Syrian Arab Republic	33	12	45
United Arab Emirates	10	13	23
Yemen	32	59	91

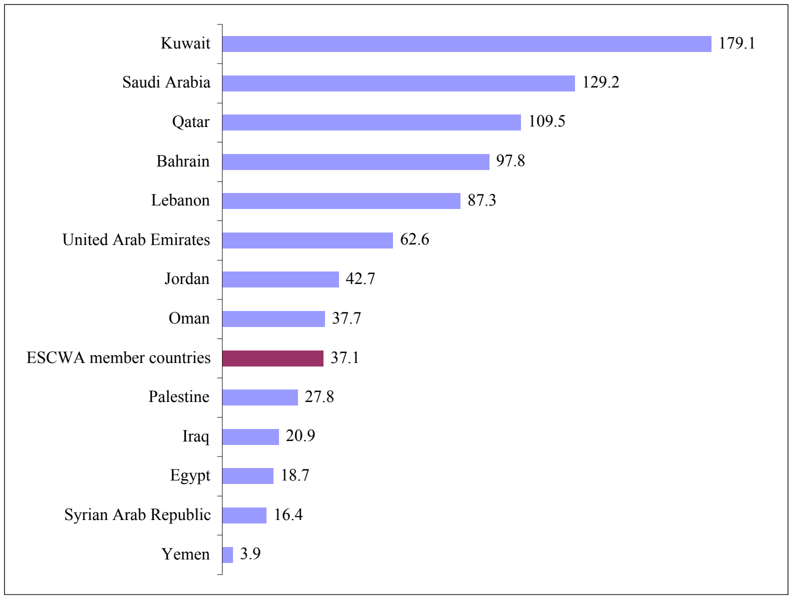
Source: Adapted from ESCWA-UNESCO, *Higher Education Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/1/Rev.1).

TABLE 3. STUDENT-TO-STAFF RATIO IN HIGHER EDUCATION IN ESCWA MEMBER COUNTRIES

	Academic year	Student to staff ratio
Bahrain	2001	29
Egypt	1999	..
Iraq	1998	22
Jordan	2001	24
Kuwait	1999	19
Lebanon	1999	12
Oman	2001	10
Palestine	2001	34
Qatar	2001	13
Saudi Arabia	1999	19
Syrian Arab Republic	2001	42
United Arab Emirates	1998	14
Yemen	2000	43

Source: Adapted from ESCWA, *Statistical Abstract of the ESCWA Region* (E/ESCWA/STAT/2002/6).

Figure 5. Higher education expenditure in ESCWA member countries, 1996
(*US$ per capita*)



Source: Adapted from ESCWA-UNESCO, *Higher Education Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/1/Rev.1).

TABLE 4. HIGHER EDUCATION EXPENDITURE AS A PERCENTAGE OF GDP IN THE ARAB COUNTRIES, 1996

High: Above 1.5 per cent		Medium: 1.0-1.5 per cent		Low: Below 1.0 per cent	
Jordan	3.1	Sudan	1.4	Qatar	0.8
Palestine	2.3	Algeria	1.4	Iraq	0.5
Lebanon	2.0	Syrian Arab Republic	1.3	Djibouti	0.4
Saudi Arabia	1.8	Yemen	1.3	Libyan Arab Jamahiriya	0.4
Egypt	1.6	Morocco	1.2	United Arab Emirates	0.3
		Bahrain	1.1	Somalia	0.2
		Kuwait	1.1		
		Oman	1.1		
		Tunisia	1.1		
		Mauritania	1.0		

Source: Adapted from ESCWA-UNESCO, *Higher Education Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/1/Rev.1).

TABLE 5. HIGHER EDUCATION EXPENDITURE PER STUDENT IN ESCWA MEMBER COUTNRIES, 1996

	Higher education expenditure per student (in United States dollars)
Bahrain	6 621.5
Egypt	1 118.7
Iraq	1 761.7
Jordan	2 112.4
Kuwait	8 666.4
Lebanon	3 087.3
Oman	9 539.0

TABLE 5 (*continued*)

	Higher education expenditure per student (in United States dollars)
Palestine	1 222.9
Qatar	7 062.2
Saudi Arabia	9 946.2
Syrian Arab Republic	931.0
United Arab Emirates	8 275.5
Yemen	515.0

Source: Adapted from ESCWA-UNESCO, *Higher Education Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/1/Rev.1).

TABLE 6. UNIVERSITY STUDENTS AND GRADUATES IN ESCWA MEMBER COUNTRIES, 1996

	Bachelor		Masters		Ph.D.		Total	
	Students	Graduates	Students	Graduates	Students	Graduates	Students	Graduates
Bahrain	5 250	1 139	273	77	46	8	5 569	1 224
Egypt	836 055	91 511	43 204	5 984	20 522	3 421	899 781	100 916
Iraq	154 960	30 164	4 958	652	3 546	709	163 464	31 525
Jordan	81 057	13 930	5 731	1 324	2 043	391	88 831	15 645
Kuwait	26 004	6 225	849	205	140	25	26 993	6 455
Lebanon	71 220	9 501	2 506	666	590	116	74 316	10 283
Oman	6 414	1 221	86	27	152	27	6 652	1 275
Palestine	49 780	5 492	2 792	695	421	76	52 993	6 263
Qatar	7 477	1 289	78	23	57	10	7 612	1 322
Saudi Arabia	222 999	26 687	5 570	1 280	2 226	450	230 795	28 417
Syrian Arab Republic	168 475	14 170	2 653	495	495	90	171 623	14 755
United Arab Emirates	14 691	1 691	213	57	294	53	15 198	1 801
Yemen	112 205	8 298	147	39	159	31	112 511	8 368

Source: Adapted from ESCWA-UNESCO, *Higher Education Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/1/Rev.1).

E. TECHNOLOGICAL BALANCE OF PAYMENTS

Technology transfer activity between countries is evaluated in a “technological balance of payments (TBP)” index which records the flow of funds related to intellectual property. This indicator can equally provide information on technology diffusion and competitiveness when employed in comparing data among countries, on condition that similar data collection methods be used. TBP covers the purchase and sales of “disembodied” technology, such as property rights, licenses, and technical assistance, as well as payments not related to technology, namely management services.[21] However, it does not, account for technology exchanges that do not involve payment. This is the case in cross-licensing agreements or know-how transfer. Furthermore, around two-thirds of total recorded values in TBP are the result of transfer pricing, which is a frequent practice in multinational companies.[22]

There are many other indicators of technology transfer often preferable to TBP, which is still extensively used. OECD has proposed methods for the compilation and use of TBP data and has been collecting and publishing this information since 1982,[23] and has made recommendations on how TBP may be applied to measure technology transfer activity (see table 7).

[21] N. Vonortas. “Science, Technology, and Innovation Indicators”, George Washington University, USA, 2002.

[22] Ibid.

[23] OECD, TBP Manual, “The measurement of scientific and technological activities: proposed standard method of compiling and interpreting technology balance of payments data”. Paris, OECD, 1990.

Data availability on TBP in ESCWA countries, or the Arab countries for that matter is lacking, presenting a limiting factor for analysts and policy makers, especially in mapping technology transfer and analysing competitiveness and productivity of the region.

TABLE 7. SUGGESTIONS GIVEN FOR THE CALCULATION OF TECHNOLOGICAL BALANCE OF PAYMENTS

Factors to be included	Factors to be excluded
Invention rights (buy, sell, and usage rights)	Commercial, financial, management, and legal advice
Know-how (not covered by patents)	Advertisement
Trademark (franchising)	Insurance
	Transportation
	Films and sounds recording
	Copyrighted material
	Design
	Software

Source: OECD, TBP Manual, "The measurement of scientific and technological activities: proposed standard method of compiling and interpreting technology balance of payments data". Paris, OECD, 1990.

F. INTERNATIONAL TRADE IN HIGH TECHNOLOGY

The trade activity of a country in high technology provides insight into its competitiveness. One important measure is to look into the percentage of trade in high technology goods with respect to the country's total exports. This indicator can be evaluated at the sectoral or the product level.

Data collected on high technology are often too general to allow reliable analysis. Even though using the data in conjunction with other data on R and D would help attain a more comprehensive view, it is not possible to clearly determine high technology content in a product. Moreover, the lack of standards in the measurement of technological intensity, leads firms to classify products with similar technology content differently. To resolve this difficulty, OECD and Eurostat have produced a list of products stipulating their technology content.

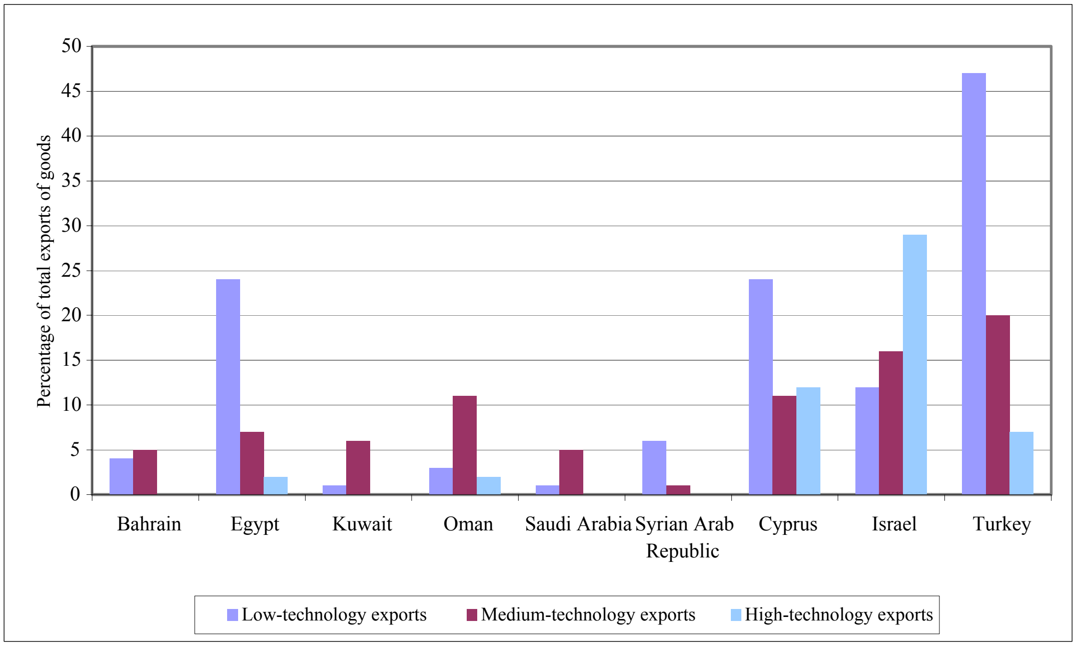
In its 2001 Human Development Report, UNDP classifies exports as "low", "medium" or "high" technology (see table 8). According to this classification, data show that a majority of ESCWA member countries do not export any high-technology content. The two exceptions are Egypt and Oman where high-technology exports account for a mere 2 per cent of their total goods exports, each. Medium-technology exports, such as various types of manufacturing equipment, are only slightly more common from ESCWA member countries (see figure 6).

TABLE 8. DEFINITION OF "LOW", "MEDIUM" AND "HIGH" TECHNOLOGY EXPORTS

Low technology	Textiles, paper, glassware and basic steel and iron products (including sheets, wires and unworked casting).
Medium technology	Automotive products, manufacturing equipment (including agricultural, textile and food processing machinery), some forms of steel (tubes and primary forms) and chemical products (polymers, fertilizers and explosives).
High technology	Electronics and electrical products such as turbines, transistors, televisions, power generating equipment and data processing and telecommunications equipment, as well as other high-technology exports, namely, cameras, pharmaceuticals, aerospace equipment and optical and measuring instruments.

Source: UNDP, *Human Development Report 2001: Making New Technologies Work for Human Development*, New York, Oxford University Press, Inc., 2001.

Figure 6. Low, medium and high technology exports from selected ESCWA member countries compared with selected neighbouring countries, 1999



Source: Adapted from UNDP, *Human Development Report 2001, Making New Technologies Work for Human Development*, New York, Oxford University Press, Inc., 2001.

One of the main characteristics of the countries that have achieved a high human development index is the impressive ratio of technology exports to the total export of goods, representing an average of over 70 per cent of their exports. Some Arab countries show respectable figures in this indicator, namely: Tunisia, 71 per cent; Morocco, 34 per cent; and Egypt, 33 per cent. The bulk of these figures represents low technology exports (52, 22 and 24 per cent for Tunisia, Morocco and Egypt respectively) and medium technology exports (16, 12 and 7 per cent respectively). For the Arab countries better positioned in the human development index, either their technology exports represent a small percentage of the total exports (ranging between 7 and 9 per cent) or no data are available. The same situation applies for the rest of the Arab countries.

G. CONTRACTS

Measuring and observing patterns of technology transfer provides insight into the strengths and weaknesses of policies set forth by national STI systems, with a view to ensuring sustainable benefits from these activities. Technology transfer occurs through contractual agreements, which are often implemented by the Government.

In ESCWA member countries, much of the production and services technologies have been acquired through technology transfer, both in the public and private sectors.

Up-to-date information on technology transfer is not always available or reliable, as not all countries regularly report on their contractual activity. Some countries in the region periodically publish data on tenders sought and contracts concluded, which is compiled by specialized journals such as the *Middle East Economic Digest* (MEED) (see box 7). Figures quoted here do not necessarily reflect the full extent of activity or expenditures of technology transfer, since not all contracts are listed in MEED and some that are listed do not have their values stated, particularly those recently concluded in Iraq. Moreover, it is highly unlikely that all defence contracts are reported here.

Box 7. Contracts in ESCWA member countries, January 1992 – June 2003

The following discussion is an overview of contracts concluded in ESCWA region during the period January 1992 - June 2003. Although these contracts do not necessarily imply technology transfer per se, they involve varying extents of technology acquisition, reflecting certain technological needs across the sectors.

The total number of contracts concluded in ESCWA member countries between January 1992 and June 2003 was around 4778, amounting to almost US$ 289 billions. Figure 7 shows that Saudi Arabia and the United Arab Emirates have concluded the largest number of contracts during this period. Together they account for 43 per cent of the region's contractual activity, and were mainly involved in the construction and expansion of oil and gas, petrochemical, and power facilities, whereas other countries as Lebanon and Yemen had fewer contracts concluded each year. In 2001 and 2002, there was a significant 64 per cent decline in the number of contracts concluded across the entire region, where approximately 421 and 150 contracts were concluded respectively.

However, the year 2003 appears to be advancing in a different direction. So far, in the first half of 2003, a total of 159 contracts have been concluded in the region, which is far more than the total for 2002. Due to the circumstances, Iraq saw a rise in the number of contracts, particularly for infrastructure, during the months of May and June this year.

Contract expenditure in ESCWA member countries had steadily been increasing through the years 1992 to 2000, and then peaked sharply in 2001 due mainly to three countries, Oman, Saudi Arabia, and the United Arab Emirates. In 2001, Oman purchased contracts worth around US$ 1.3 billion to build the Oman-India fertilizer plant. The United Arab Emirates spent US$ 15 billions to acquire new commercial aircraft, and almost US$ 779 millions for the construction of a power and water desalination complex in Fujairah. Meanwhile, Saudi Arabia concluded a contract for a substation package worth US$ 32 billions, and another for expanding the GSM network estimated at around US$ 826 millions. Contract values in 2002 witnessed a deep plunge, further highlighted by the peak in 2001 and the considerable increase for the first half of 2003 (see figure 8). The latter is a consequence of the purchase of more commercial aircraft, worth around US$ 5.1 billion and US$ 19 billions, in Qatar and the United Arab Emirates, respectively. Oman has also contributed to the rapid growth in the first six months of 2003, investing heavily in its oil and gas industry.

Figure 9 illustrates the evident concentration of contractual activity in the industry and infrastructure sectors, each accounting for around 30 per cent of the total activity. Of ESCWA member countries, those with the most active industry and infrastructure sectors between January 1992 and June 2003 included Egypt, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates. Saudi Arabia also showed significant activity in the services sector, concluding 221 contracts, or around 28 per cent of all services contracts concluded in the period mentioned. The United Arab Emirates followed with 148 services contracts, or around 20 per cent. Meanwhile, Iraq and the Syrian Arab Republic concluded eight and nine services contracts respectively, which is considerably low, noting that 7 out of the 8 services contracts in Iraq were concluded between April and June 2003.

Despite the fact that many ESCWA member countries have primarily agricultural economies, the agriculture sector has exhibited the least contractual activity between 1992 and 2003, with six or less contracts for most ESCWA member countries, with the exception of 11 for Egypt.

Figure 10 displays the evolution of industrial contracts concluded in ESCWA member countries. Between January 1992 and June 2003, most industry contracts were concluded in the oil and gas sector, namely 616 across the entire region, although the cement and glass, metallurgical, and petrochemical sectors also witnessed significant activity. Egypt has largely been involved in the production of cement, and has built and expanded several cement plants over the last 10 years. Starting 1998, contracts concluded for Egypt's most recent cement plant in Beni Suef have totalled around US$ 410 million.

Saudi Arabia has awarded the most attention to waste management in the region, concluding 21 contracts worth almost US$ 450 millions during 1992-2003. It has also invested the most in its petrochemical industry, with around 74 contracts worth over US$ 38 billions. The distribution of industry contracts across the different sub-sectors is shown in figure 11.

Over the period January 1992 through June 2003, a total of 1,484 contracts were awarded in the infrastructure sector, valued at over US$ 63 billion in sum. Fluctuations in infrastructure investment are visible in figure 12, and there appears to be no correlation with the pattern observed in figure 10 for the industry sector. The majority of contracts concluded in the infrastructure sector were for the construction and expansion of national power networks, particularly in Saudi Arabia and the United Arab Emirates, which together accounted for around 43 per cent of the total power-related contracts concluded between January 1992 and June 2003. Water desalination, waste water management, and other water issues were also awarded a great deal of attention during this period throughout the whole region. Meanwhile, telecommunication work, such as upgrading the fixed-line network and expanding the mobile network, was prevalent particularly in Egypt, Saudi Arabia and the United Arab Emirates (see figure 13).

Source: Middle East Economic Digest (MEED), Contract issues, February 1992 through June 2003. Available at: http://www.meed.com.

Figure 7. Distribution of contracts concluded in ESCWA member countries, January 1992 – June 2003

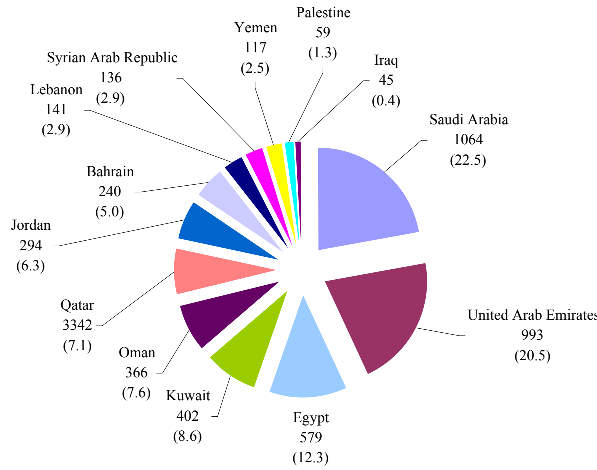
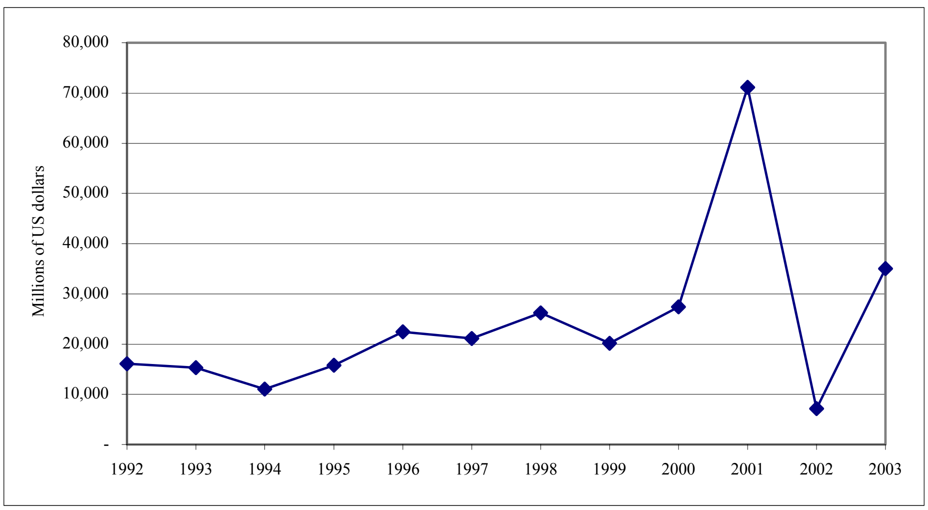
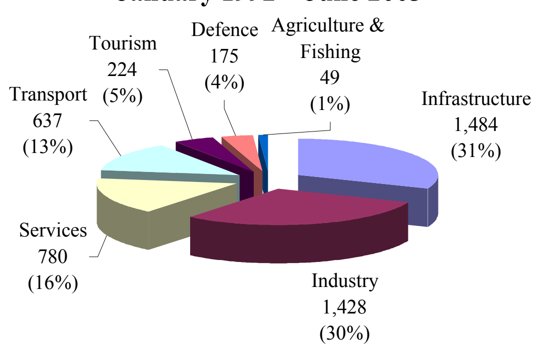


Figure 8. Value of contracts concluded in ESCWA member countries, January 1992 – June 2003



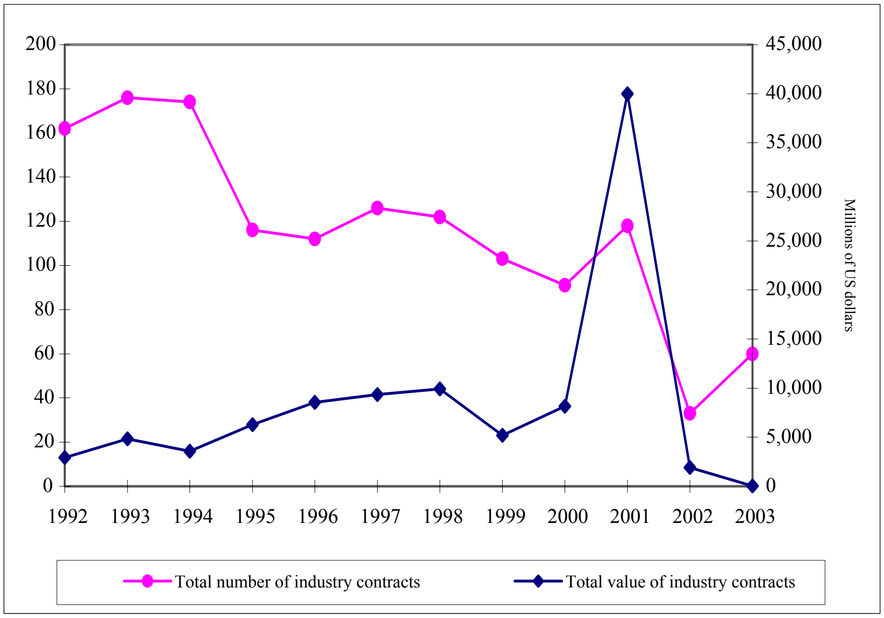
Source: Middle East Economic Digest (MEED), Contract Issues, February 1992 through June 2003. Available at: http://www.meed.com.

Figure 9. Distribution of contracts concluded in ESCWA member countries by sector, January 1992 – June 2003



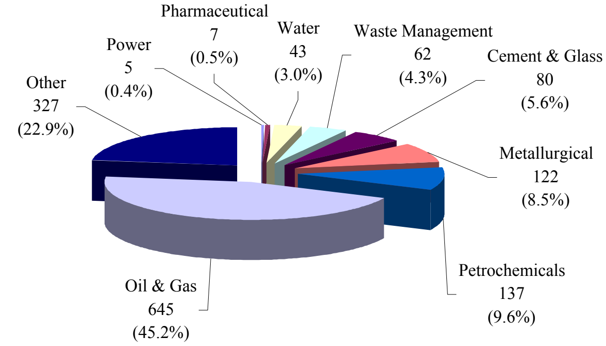
Source: Middle East Economic Digest (MEED), Contract Issues, February 1992 through June 2003. Available at: http://www.meed.com.

Figure 10. Total number and value of industry contracts concluded in ESCWA member countries, January 1992 – June 2003



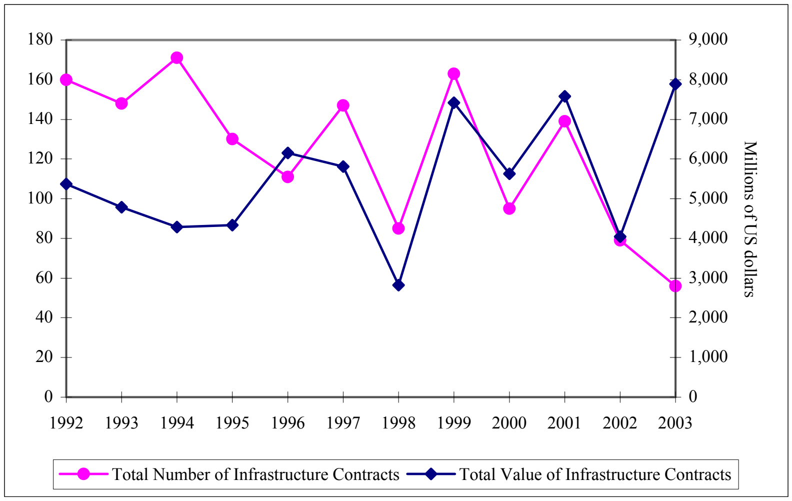
Source: Middle East Economic Digest (MEED), Contract Issues February 1992 through June 2003. Available at: http://www.meed.com.

Figure 11. Sub-sectoral distribution of industry contracts concluded in ESCWA member countries, January 1992 – June 2003
(*Percentage*)



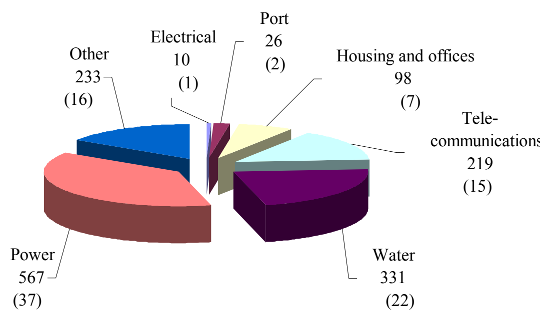
Source: Middle East Economic Digest (MEED), Contract Issues February 1992 through June 2003. Available at: http://www.meed.com.

Figure 12. Total number and value of infrastructure contracts concluded in ESCWA member countries, January 1992 – June 2003



Source: Middle East Economic Digest (MEED), Contract Issues, February 1992 through June 2003. Available at: http://www.meed.com.

Figure 13. Sub-sectoral distribution of infrastructure contracts concluded in ESCWA member countries, January 1992 – June 2003
(*Percentage*)



Source: Middle East Economic Digest (MEED), Contract Issues, February 1992 through June 2003. Available at: http://www.meed.com.

H. LINKING STI AND SOCIAL INDICATORS

Linking social and STI indicators holds great importance in assessing national receptiveness to specific innovative inputs and, more generally potential for STI capacity building. Particular social problems may also be amenable to specific technology inputs that may be in need of customization to suit national and local needs.

In rural areas, where communities are impoverished and have limited access to education and health services, technologies such as ICTs could open doors to solutions for illiteracy, both traditional and technological, health awareness, dissemination of basic skills, and so on. Human resource development at all levels of the community will improve access to the job market and help alleviate poverty. Special emphasis must be given to women and youth in community development. Other technologies, such as new materials and biotechnologies also hold promise for a variety of applications targeting the improvement of agriculture and food-processing sectors.

One way to account for the aforementioned problems of rural communities is by establishing ICT community centres. The community centres seek to transfer technologies to remote areas in an effort towards

alleviating poverty and providing new work opportunities for individuals in local communities. The centres also enhance the level of education by introducing ICTs to schools. An initiative of Information Technology Community centres was developed and implemented in Jordan (see box 8).

Box 8. Jordan's Information Technology Community Centres (JITCC)

A national strategy was developed in Jordan to implement information technology community centres across the country with the aim of providing all Jordanians, especially those living in rural areas with ICT access, instil ICT awareness, and train Jordanians to use new ICT skills. The goals of the centres include decreasing poverty, increasing employment opportunities, and improving education and productivity. These goals will give rural Jordanian communities a chance to prosper by means of technology in the age of information.

The information technology community centres in Jordan target men and women, students, teachers, doctors, workers and farmers. Each individual will be shown how to use ICTs in his daily life and occupation. The student, for example will be encouraged to conduct researches using the Internet, doctors will be shown the medical online sites, and farmers will be taught how to get daily prices by means of a handheld device.

The National Information centre will be responsible for the execution of the project. The following will be established:

(a) Eleven centres in each governorate other than Amman;
(b) Two centres in Amman;
(c) Three centres in Badia.

Each centre will have an average of ten up-to-date personal computers. The Ministry of Education will provide the linkage between the centres and the educational system in Jordan. The centres' future plans include e-services, e-government training and e-learning.

Source: Jordan Information Community Centers, 2001. Available at: http://www.jitcc.gov.jo.

ESCWA member countries share many common socio-economic problems, such as high illiteracy and unemployment rates, lack of gender empowerment, low income per capita, and low productivity in the agriculture sector. According to the most recent statistics, Jordan had the lowest illiteracy rate among ESCWA member countries in 1999 and 2000 at 10.8 per cent[24] and 10.2 per cent,[25] respectively. Egypt and Yemen are severely plagued by illiteracy, with rates of 44.7 per cent and 53.8 per cent in 2000, respectively. The higher illiteracy rates are among females in these two countries. In Egypt, 56.3 per cent of women above 15 years of age are illiterate, and in Yemen 75 per cent of women 15 years or older are illiterate. All ESCWA member countries witnessed a slight decrease in the percentage of illiteracy of males and females between the years 1999 and 2000. Although data on schooling are not available for more recent years, these drastic illiteracy rates are consistent with the average years of schooling observed in 1992 (see table 9 and figure 14).

Other ESCWA member countries also had relatively high illiteracy rates in 1999, the majority ranging between 15 and 30 per cent of the total population. One solution to an inhibiting problem such as illiteracy would be to establish distance-learning programmes based on ICTs. Special programmes could also be designed to target young females in rural areas, and encourage their participation in community development

[24] UNDP, *Arab Human Development Report 2002*: *Creating Opportunities for Future Generations*, Jordan, 2002.

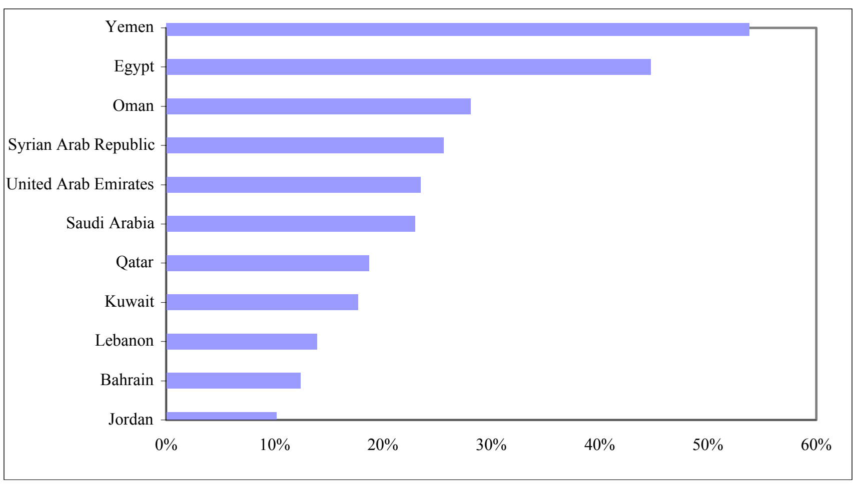
[25] ESCWA report *Statistical Abstract of ESCWA Region*, 2003 (E/ESCWA/STAT/2002/6).

TABLE 9. ILLITERACY PERCENTAGE RATES FOR PERSONS OVER 15 YEARS OF AGE IN ESCWA MEMBER COUNTRIES (1999, 2000)

	1999			2000		
	Male	Female	Total	Male	Female	Total
Bahrain	9.5	17.8	12.9	9.0	17.3	12.4
Egypt	33.9	57.2	45.4	33.4	56.3	44.7
Iraq	-	-	-	-	-	-
Jordan	5.5	16.6	10.8	5.1	15.6	10.2
Kuwait	16.0	20.6	18.1	15.7	20.1	17.7
Lebanon	8.2	20.2	14.4	7.7	19.6	13.9
Oman	20.9	40.4	29.7	19.6	38.3	28.1
Palestine	-	-	-	-	-	-
Qatar	19.9	17.4	19.2	19.5	16.8	18.7
Saudi Arabia	16.5	34.1	23.9	15.9	32.8	23.0
Syrian Arab Republic	12.3	40.7	26.4	11.7	39.6	25.6
United Arab Emirates	26.2	22.0	24.9	24.8	20.5	23.5
Yemen	33.4	76.1	54.8	32.6	75.0	53.8

Sources: UNDP, *Arab Human Development Report 2002*: *Creating Opportunities for Future Generations*. Jordan, 2002; and ESCWA, *Statistical Abstract of the ESCWA Region, 2002* (E/ESCWA/STAT/2002/6).

Figure 14. Illiteracy rates of persons over 15 years of age in ESCWA member countries, 2000
(*Percentage*)



Source: UNDP, *Arab Human Development Report 2002*: *Creating Opportunities for Future Generations*. Jordan, 2002.

Data on school enrolment in the ESCWA region are not readily available. Table 10 illustrates the average years of schooling in ESCWA member countries. One can see that female participation in education lags behind male participation according to the statistics for the year 2000. In Egypt, for example, the average years of schooling for females was 4.5 years—approximately 30 per cent less than the average years of schooling for males at 6.5 years. Kuwait had the closest average years of schooling for males and females at 7.2 and 6.9 years, respectively.

TABLE 10. AVERAGE YEARS OF SCHOOLING IN ESCWA MEMBER COUNTRIES

	1970	1992	2000		
	Total	Total	Male	Female	Total
Bahrain	2.8	4.3	..	..	6.1
Egypt	..	3.0	6.5	4.5	5.5
Iraq	..	5.0	4.6	3.3	4.0
Jordan	3.3	5.0	7.7	6.0	6.9
Kuwait	3.1	5.5	7.2	6.9	7.1
Lebanon	..	4.4	..	..	..
Oman	..	0.9	..	..	..
Palestine	..	..	..	..	..
Qatar	..	5.8	..	..	..
Saudi Arabia	..	3.9	..	..	..
Syrian Arab Republic	2.2	4.2	6.8	4.8	5.8
United Arab Emirates	..	5.6	..	..	..
Yemen	..	0.9	..	..	..

Sources: UNDP, *Arab Human Development Report 2002*: *Creating Opportunities for Future Generations*. Jordan, 2002; The World Bank Group, *World Development Indicators 2003*, Washington D.C., USA, 2003.

I. CONCLUDING REMARKS

A thorough discussion has been presented on some of the most commonly used S and T indicators, and on the increasing urgency for properly defined measurement and evaluation strategies. Each S and T-related issue discussed in this chapter, such as higher education, research and development, or patenting, generates a multitude of indicators. The indicators have been discussed according to their function in the national S and T system, an emerging concept that helps one to visualize the input, process, and output aspects of S and T.

For illustration purposes, data for a variety of the indicators discussed have also been presented, revealing inadequacies in data collection in ESCWA member countries, rendering it difficult to truly assess national science and technology capabilities. For instance, the most recent data found on R and D and higher education dates back to 1996. It is therefore extremely difficult to draw relevant conclusions and formulate relevant policies for furthering S and T development without recent data. It is extremely necessary to have frequent collection for a set of standardized and internationally adopted S and T indicators.

Other data, such as those on patenting and publishing in refereed journals, are more recent, and in fact leave much to be desired in ESCWA member countries. The number of registered patents and published papers, both output indicators, are almost negligible compared with other countries, due to shortages in funding and full-time researchers. Without a strong human skill base, R and D activity in the region cannot flourish.

The extent of technology transfer was also examined in this chapter based on exports in low, medium, and high technology, and the extent of contractual activity. In either case, there are significant deficiencies with regards to indigenous technological capabilities in ESCWA member countries.

III. INNOVATION INDICATORS

A. MEASURING INNOVATION

The advent of the global knowledge-based economy imposes a strong need to develop and implement indicators that effectively measure innovation performance, enabling Governments and firms to adequately deal with relevant policy issues. Over the past decade, major efforts have been expended, and some significant progress made in the development of innovation indicators, by theoretical analysts, and policy researchers. A considerable volume of the literature on the subject relates to innovation at the enterprise or firm level, with national innovation constituting the resultant or cumulative impact of national firms' innovative capacity.

Selecting an appropriate set of indicators for the measurement of innovative capabilities and their impact on enterprise performance requires adequate understanding of the reasons why firms innovate, and what are the factors that support or hinder the innovation process. Both aspects are country and time specific.

Firms, and the strategies they adopt, demonstrate support for innovation by making the best of their technological resources. The scope of sources of information on innovation and technological change is also an important parameter. On the other hand, firms may face several obstacles to innovate, such as skill shortages, problems of competence and finance. These factors may be readily assessed using standard survey methods, whereas aspects relating to management styles and work ethics are more difficult to assess. Table 11 lists typical economic objectives and hampering factors of innovation activities. The need to innovate according to Schumpeter[26] is briefly described in box 9.

TABLE 11. TYPICAL ECONOMIC OBJECTIVES AND HAMPERING FACTORS OF INNOVATION

Economic objectives	Hampering factors
- Maintain or increase market share; - Open up new markets; - Lower production costs; - Replace products being phased out; - Develop environment-friendly products; - Improve production flexibility - Enhance product quality - Create better working conditions - Reduce environmental damage.	- Economic factors: excessive risks, high costs, lack of finance, pay-off period; - Enterprise factors: insufficient innovation potential; - Lack of skilled personnel; - Lack of information technology and a number of miscellaneous factors, such as lack of infrastructure; - Legislation; - Taxation.

Source: OECD, Oslo Manual, "The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data", Paris, OECD, 1997.

A good deal of the data collected on innovation are in the form of case studies that provide useful information but cannot be extended over the rest of the sectors of the economy. Additionally, focusing on a small group of R and D intensive sectors does not provide adequate information on the characteristics, structure and dynamics of innovation processes taking place elsewhere in the economy. These shortcomings necessitate a statistical approach for innovation measurement.

[26] J. Schumpeter, *The Theory of Economic Development*, Harvard University Press, Cambridge, Massachusetts, 1934.

Box 9. Why innovate?

Understanding the reason behind the need to innovate is crucial in policymaking. Schumpeter provides the following analysis:

A new technological device is often the source of advantages. Thus, in cases where an innovation will enhance productivity, the innovator might acquire a cost advantage over competition. This could allow the innovator (a) higher profits at prevailing market prices or, (b) a larger market share. In cases involving product innovation, the innovator could acquire a monopoly position, based either on a patent, or on the period it takes competitors to launch imitations. A monopoly position based on an innovative product would naturally allow an innovator higher prices than might be possible in a market where competitive products are available.

Later work on innovation has emphasized the need by an innovative firm to defend its competitive position and seek competitive advantage. An innovative firm would, thus, need to introduce innovative changes in order to prevent losing market share to another innovative competitor. Alternatively, an innovative firm may adopt an active stance in seeking to gain a strategically competitive market position. This is often achieved by developing and then attempting enforcement of higher technical standards for the product in question.

Source: Schumpeter, J. *The Theory of Economic Development*. Harvard University Press. Cambridge, Massachusetts. 1934.

Measuring the effect of non-R and D inputs on innovation is as crucial as that of R and D inputs. The resulting pattern of relation between these parameters taken across industries or in a particular industry could provide an exceedingly valuable tool for innovation and R and D policies.

The growing link between innovation policy and wider policy objectives makes it important to consider the socio-economic context in order to understand the dynamics of innovation and knowledge creation, going beyond strictly hi-tech production sectors to include the nature of activities undertaken by the service sectors, both public and private.[27]

The stage of development through which a given sector or segment may be going, might be reflected in modalities used to measure innovation. The fact that a good deal of innovative inputs are due to transfer from sources of scientific, technological knowledge and managerial practices outside ESCWA member countries must be recognized in any innovation measurement scheme.

Ultimately, the task of selecting a set of innovation indicators must be dealt with as an integral part of national STI strategy initiatives. Indicators presented in annex table 6 under the heading “product innovation and process innovation”, may be used in such initiatives. Indicators listed under these headings comprise aspects that often extend beyond mere creation of STI knowledge, and involve acquisition, dissemination and implementation of such knowledge.

At least some of the indicators directly related to innovation will require further analysis and research. Others, such as the indicator targeting assessment of technological content of exported products in relation to total exports, are already in use and methodologies for their implementation have already been developed. Nevertheless, difficulties will arise in applying all innovation indicators listed in annex table 1 in ESCWA member countries. The need for allocating sufficient resources necessary for collecting information that is directly pertinent to specific national and sectoral attributes cannot be overemphasized.

[27] K. Smith, “Innovation Indicators and the Knowledge Economy: Concepts, Results and Policy Challenges”, Norway, STEP Group, November 2000.

1. *The Oslo Manual and the Community Innovations Surveys*

Empirical measurement of innovation remains at an early stage of development. The need for new innovation indicators and the results of pilot efforts in some countries for the collection of relevant data has led to the publication of the first Oslo Manual and to the first Community Innovation Survey (CIS1) in 1992-1993.[28] Examples of areas covered in the survey include the relative importance of various sources of technological information, methods utilized for the purchase and transfer of technology, R and D cooperation, and barriers to importing innovations.

Box 10. Selected areas covered in the first Community Innovation Survey (CIS1)

Importance of various sources of technological information:

(a) Internal sources – within the company or a group of companies;

(b) Market-based sources – suppliers of materials, intermediate products and machinery, clients, competitors, consultants;

(c) Research organizations – universities, government laboratories, other technical organizations;

(d) More generally accessible information – patents, meetings of researchers, scientific publications, reports.

Methods utilized for purchasing and transferring technology:[a/]

(a) Purchase of utilization rights and patents;
(b) R and D out-sourcing to specialist companies, consultants, or research organizations;
(c) Buy-out of another company that has the required capabilities and knowledge;
(d) Purchase of machinery with embodied technology;
(e) Hiring of specialized personnel from universities, other companies and so on;
(f) Informal relationships with universities, other companies and so on;
(g) Formal R and D cooperation such as with research joint ventures.

R and D cooperation with different kinds of organizations:[b/]

(a) Companies;
(b) Universities;
(c) Government laboratories.

Barriers to innovation import:

(a) Economic factors – high risk, lack of resources, high cost, long pay-back period;

(b) Factors internal to the company – insufficient innovation capability, lack of specialist personnel, lack of information over the related markets and technologies, resistance to change, lack of opportunities for collaboration with other organizations, and so on;

(c) Other factors – lack of technological opportunities, regulation, uninterested clients, and so on.

Source: N. Vonortas, "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

a/ The respondent is asked to indicate whether a method is utilized for purchasing and transferring technology from six geographical regions three of which are European (national, EU, outside the EU), and three non-European (US, Japan, other).

b/ In the six geographical areas: Europe (national, EU, outside the EU), US, Japan, or Other.

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[28] N. Vonortas, "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

Several important weaknesses of innovation measurement inherent in the methodologies propounded in the first Oslo Manual were illustrated by CIS1, namely, the fact that the survey covered only manufacturing and production innovations, and did not cover non-technological innovations including organizational operations.

The CIS1 equally collected information about each company it surveyed, namely its size, sector, geographical location, overall innovation capability, and so on. One of the observations made highlighted the fact that sales from innovative products did not vary greatly with respect to sizes of the manufacturing firms. The results also suggested pervasiveness of innovation across different sectors as well as types of firms. Data on innovation expenditures included non-R and D innovation costs as well as investments related to innovation. That is, apart from identifying costs related to product design, training, and so on, the CIS1 provided information on the acquisition of new technology, such as investment in new machinery and equipment.[29]

Data gathered on the basis of the first Oslo Manual fall into seven basic fields of analysis: corporate strategy, knowledge diffusion, sources of innovation ideas, barriers to innovation, innovation inflows, innovation outflows, and the role of government policy in manufacturing innovation.

However, data produced by this survey were found to be too aggregate to provide detailed explanation on knowledge flows and transfer. Thus, the second Oslo Manual, OECD 1997b, was launched incorporating a number of basic changes, including the following:

(a) An improved conceptualization of the innovation process and its impact on policy matters;
(b) A broader spectrum of sectors and activities;
(c) The results of a larger number of national and international innovation surveys.

One of the most important changes introduced in the second Oslo Manual has been the extension of innovation measurement to include services, in terms of value added to the national product and as a measure of the country's innovative driving force and contributions to global innovation. Due to the multifaceted nature of innovation in services and consequently the difficulty of measuring it, the second Oslo Manual covers only those services that have well-defined markets. These include communications, finance insurance, real estate, and entertainment services, and exclude government, health, social, and educational services. Clearly, taking such information into account expands the concept of innovation to incorporate the creation or improvement of methods to provide services.[30]

There were prospects for further expansion of the definition of innovation to include organizational changes as well. Due to the complexity of measuring such information, the second Oslo Manual maintains its focus on products and production processes. It also includes other important improvements including sample definition and advice on sample selection, and methods of survey implementation. Furthermore, the questions related to innovation are presented in such a way that the respondent will provide a more evaluative reply rather than a straightforward quantitative one.

Three significant aspects of collection and presentation of survey results were also dealt with, namely, companies that refuse to participate, data confidentiality and data presentation in an unbiased manner for better comparability.

The second Community Innovation Survey (CIS2) was conducted on the basis of this improved manual in 1997-1998. CIS2 provided data at the firm level for around 41,000 firms in thirteen European countries.[31]

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[29] K. Smith, "Innovation Indicators and the Knowledge Economy: Concepts, Results and Policy Challenges", Norway, STEP Group, November 2000.

[30] N. Vonortas, "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

[31] Includes the same countries that participated in CIS1 (12 EU member countries and Norway).

CIS2 provided a wide variety of indicators, including the percentage of innovating firms within the totality of firms under consideration, innovation expenditure and its breakdown, as well as the percentage of sales that can be attributed to innovative products. For the sample of service sector enterprises considered, the survey came up with a number of intriguing results. Thus, it was found that a little over half of the service enterprises covered were engaged in innovative activities, with shares being proportional to company size. Computer and telecommunications services appeared to top the list of innovative enterprises while the transport service sector remained close to the lower end.

The most widespread aim of innovation was found to be the improvement of the quality of services offered. Almost half of the service enterprises were engaged in R and D, and almost a quarter had cooperative arrangements with other enterprises or organizations.

The third Community Innovation Survey (CIS3), 2001-2002, was still being carried out across Europe at the time of writing. Issues debated in preparation for this survey include:[32]

(a) Explicit inclusion of the term "technological" in the definition of innovation in the questionnaire;
(b) Detailed treatment of expenditure on innovation;
(c) Service sales breakdown;
(d) Inclusion of new questions to broaden the definition of innovation.[33]

Some suggestions for improving the survey, especially in covering the service sector enterprises, include extending the sectoral coverage and lowering the firm size limits. It was also advisable to focus on organizational and not just technological innovation, especially when comparing enterprises across different sectors. Here, measuring knowledge management is valuable for assessing the effectiveness of organizational changes being implemented.

2. *Object and subject based approaches*[34]

Data on innovation collected from industry can be object-based, collected at the product level, or subject-based data, collected at the level of the organization. Each set has merits and demerits, and it has often been suggested that the two be combined.

(a) *Object-based approach*

As indicated above, object-based data is applied at the product level, with focus on innovation counts, such as patent data. In general, surveys implementing this approach, such as the Science and Technology Policy Research Unit (SPRU)[35] and the Small Business Administration (SBA) surveys, are conducted occasionally and not on periodic basis.

Several problems arise with the object-based approach, especially in relating the results of the survey on a given sample to the total economic population. The results generated are also often survey and country specific, limiting their use for international comparisons. Moreover, object-based surveys tend not to be comprehensive, as they exclude various types of innovation.

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[32] Archibugi and Sitilli, "The direct measurement of innovation: the state of art", conference "innovation and enterprise creation: statistics and indicators," France, 23-24 November 2000. Available at: http://www.cordis.lu/innovation-smes/src/statconf4.htm.

[33] A sample of the harmonized questionnaire, as implemented in the United Kingdom, can be found on the Department of Trade and Industry web site, available at: http://www.dti.gov.uk.

[34] This section draws largely on Archibugi and Sitilli, "The direct measurement of innovation: the state of art", conference "innovation and enterprise creation: statistics and indicators", France, 23-24 November 2000. Available at: http://www.cordis.lu/innovation-smes/src/statconf4.htm.

[35] The SPRU is a unit within Sussex University at Brighton, England.

(b) *Subject-based approach*

In the subject-based approach, organizations are asked to respond to a questionnaire requiring both quantitative and qualitative answers about their innovating activities. Over the last few decades, such surveys have been conducted occasionally, but have largely reflected the purposes of specific ventures. The first major effort to implement this approach on an international level is the Community Innovation Survey (CIS), which is hoped to be conducted on a periodic basis.

One of the most important features of this approach—highly characteristic of the CIS—is the fact that different kinds of data can potentially be linked, similar to R and D surveys. By examining the innovating activities at the organization level, subject-based surveys provide information on the process and impact of innovation, rather than just its outputs, as in object-based surveys.

(c) *A look at both approaches*

The object-based and subject-based approaches highlight different aspects of innovation, and are not necessarily being evaluated as two different modalities for innovation measurement. In fact, their reconciliation is under consideration, possibly for adoption in the next CIS. Table 12 provides a summary of the features of the two approaches.

Since the object-based approach employs a more standardized data collection method, it may be deployed periodically and is therefore useful to compare time related changes, namely:

(a) Rate, or intensity, of innovation produced each year;
(b) Direction or technical field in which innovation occurs.

This approach may help public or business organizations monitor which fields are progressing more dynamically, given that the information is both direct and timely.

Meanwhile, subject-based data are not as standard or comparable, making it difficult to increase the periodicity. Nonetheless, the subject-based approach supersedes the object-based approach in international comparability. This is due to the fact that data on innovation counts from different countries have so far proven to be difficult to compare since each country gathers the data according to its own methodologies and criteria.

TABLE 12. FEATURES OF THE OBJECT-BASED AND SUBJECT-BASED APPROACHES

Features of the approach	Object-based approach	Subject-based approach
Unit of analysis	Technological innovation	Firm
Method of collecting information	Collected from different sources such as new product announcements, expert surveys, innovation inventories, bibliometric directories	Collected at the firm level, by mail questionnaires or direct interview
Phase of the innovation process recorded	Records information on the output of the innovation process	Records information on the input of the innovation process, and on the impact of innovation
Periodicity	Occasional surveys	Occasional surveys. Now data collection is becoming periodical via the Community Innovation Survey (CIS)
Coverage	Samples of successful innovations, information on innovations introduced by both the business and the non-profit sectors	Successful and unsuccessful innovative activities. Innovating and non-innovating firms. Includes manufacturing and service industries
Main criteria of classification	Technological field Product Firm's principal economic activity	Firm's principal economic activity Main user sector Firm size
Typical examples	SPRU innovation survey, Small business administration	Italian survey, Community Innovation Survey

Source: N. Vonortas, "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

3. *Where and how innovation might be measured*

The following paragraphs briefly outline a few of the factors and outline possibilities for their evaluation in what is sometimes termed an innovation audit. Innovation audits may be conducted nationally, for a given sector or group of firms and even at the level of an individual firm. Naturally, there is concern about national innovation audits. However, as indicated above, national capacity for innovation is to be regarded as closely related to the ability of enterprises to innovate.

Innovation audits may be simplified by confining attention to specific firm classes and levels of technology; firms can be grouped according to criteria such as the sector of main economic activity. The group of technologies to which an innovation belongs may also introduce much needed simplification of an innovation audit.

(a) *Public policy and corporate strategies*

Public policy plays a major role in promoting or discouraging innovative performance at the national and firm levels. Both direct and indirect stimuli/hindrances are possible. Public policy will tend to impact education and the supply of skills in a more or less direct manner. Taxation policy and accounting regulations, industrial promotion schemes, the legal system of intellectual property rights, procedures that need to be followed in cases of litigation and bankruptcy may exert extremely powerful, effects on innovation albeit mostly indirect, Parameters in this area may be examined through questionnaire surveys at the firm level. Public policy plays an important part in preparing the stage for knowledge diffusion, another important parameter to consider in evaluating innovation capabilities.

Equally important are corporate strategies, because they impact the manner in which firms develop their markets and the relative importance they grant to various strategic choices available to them for improving their productivity and competitiveness (see box 11 for categories of innovation indicators based on potential policy intervention areas).

Box 11. Categories of innovation indicators according to policy intervention areas

Composite indicators used to measure the complex nature of innovation activity can be classified into categories according to areas in which policy intervention is needed most. These include:

(a) Framework and infrastructure conditions that determine national and enterprise abilities for establishing rules and expanding the range of opportunities for innovation. They include both policy and physical components, including ease of communications within and between organizations;

(b) Science and technology capabilities, including the manner by which knowledge is generated and utilized, the availability of support systems for basic and applied research and funding programmes for public good, and the abilities to design and implement strategic R and D planning;

(c) Human resource development factors, including higher educational systems and specialized technical training systems;

(d) Social and cultural factors that influence how innovation can be produced, accessed and implemented effectively by enterprises.

(b) *Knowledge creation and diffusion*

Without possibilities for unhindered knowledge creation and diffusion among and within firms, it would be quite difficult to realize an innovation. Certain aspects of knowledge creation are described in box 12. On the other hand, the following are aspects to consider when measuring knowledge diffusion:

(a) Flow of innovation and technological change from one industry or firm to another;
(b) Inter-firm cooperation, perhaps through shared R and D;
(c) Licensing and joint ventures.

Impact on productivity can be considered and distinction may be made between internal and external sources of knowledge and technological change. Reference may also be made to the destination of the results of innovating activities.

Diffusion of advanced technological knowledge through other countries, sectors, regions and firms, may be assessed with reference to whether such diffusion has proceeded on the basis of market or non-market mechanisms. Either way, diffusion may be traced from the date of its initial introduction to the dates of its implementation in different countries, regions, industrial sectors, markets and firms.

Box 12. Organizational knowledge creation

According to Nonaka and Takeuchi, knowledge creation leads to continuous innovation which in turn leads to competitive advantage. The key players in the knowledge creation process include all organizational departments and employees. Managers play a role through directing chaotic ideas into meaningful knowledge formulation. The organization on the other hand, should satisfy five conditions to enable knowledge creation:

1. Intention: which is the aspiration of the organization to reach its aims.

2. Autonomy: in order to enhance the knowledge creation process, the organization is supposed to give autonomy to its individual employees. Independently thinking employees are self-motivated to search for new ideas and increasingly assimilate more knowledge.

3. Fluctuation and creative chaos: total disorder is not the intended meaning for chaos, in fact, what is meant is a hard-to-predict pattern. Fluctuation stimulates interaction with the surrounding environment. Yet, this kind of chaos does not come on its own; it should be induced by the upper management through general plans or challenging requirements.

4. Redundancy: when information is transmitted from one employee to another even if others do not immediately need the information, redundancy is achieved. In this respect, redundancy does not eliminate efficiency. One way of presenting redundancy to the organization would be by rotating employees frequently.

5. Requisite variety: the employees are required to have different and immediate sources of information about a certain subject. When all employees have the same amount and degree of information, they better interact with each other to achieve their set goals.

Source: I. Nonaka, and H. Takeuchi, *The Knowledge-Creating Company*, Oxford University Press, New York, 1995.

(c) *Impact of innovation*

Using indicators such as the proportion of sales due to technologically new or improved products gives insight to the impact of innovation. Here, distinction may often be made between technologically new and improved products and varied production methods. The results of innovation may also be evaluated through comparing sales, exports, numbers of employees and operating margin for a particular span of time. The impact of innovation can also be measured on the use of factors of production, namely, manpower, material and energy consumption and utilization of fixed capital, cost reduction achieved by implementation of technological process innovations.

The technological group to which the innovation belongs may be determined by identifying the most important innovation of the firm. The probable sector of utilization may be determined by identifying the "proportions of sales due to technologically new or improved products by the sector of main economic activity of the firm's main client(s) for those technological product innovations".[36]

[36] OECD, Oslo Manual, "The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data", Paris, OECD, 1997, p. 56.

Surveys may also ascertain other aspects of diffusion, including the extent to which innovations in the form of new embodied technology are used in production, or collect information about the use, planned use and non-use of certain specified technologies. It is important to bear in mind that a technology must be sufficiently used so that the statistics collected about its use and planned use across a specific industrial sector provide significant information for policy makers.

B. Technological product and process innovation

The entire world has clearly been in the throes of a major technological revolution. Changes engendered by this revolution span a range of technologies and their fields of application. The world economy is continuously being remodelled by changes due to new ICTs accompanied by fundamental breakthroughs in biotechnology and materials science. Many such changes have already made their impact on the world economy, through specific product and process innovations. Nevertheless, our understanding of the manner in which technological changes and related innovations impact total factor productivity and output growth rates remains inadequate. Achieving an understanding as such is important for a number of reasons. In particular, appreciation of the impact of technological product and process innovation (TPP) on the economy is essential in devising viable capacity-building policies and related implementation strategies. Box 13 and the adjoining paragraphs provide definitions and a summary discussion of some of the main concepts encountered in the analysis of product and process innovation.

In general, introducing TPP innovation involves activities on a wide front aimed at securing inputs of scientific, technological, organizational, financial and commercial origins. A whole collection of such inputs will play an important part in creating conditions that eventually allow implementation of technologically new or improved products or processes.

A given entity, firm or institution, may engage in successful innovation leading to the creation and commercialization of a new or improved product or process. However, innovation may be aborted due to difficulties encountered during various stages of the process of introducing innovative inputs in the product or process targeted. TPP innovations may also be aborted due to changes in market conditions, in addition to regulatory or legislative changes, either national or international.

It is essential to recognize that a TPP innovation may only be regarded as such if it has been implemented. That is if it has actually been introduced into commercial application, in the case of product innovation, or used within a production process, in the case of process innovation. On the other hand, innovative firms may be engaged in "ongoing innovation" in which activities intended to lead to new or improved technological inputs or changes are in progress but have not yet reached a stage of commercial implementation.

Box 13. Definitions of technological product and process innovations

Technological product and process (TPP) innovations involve a collection of activities aimed at securing scientific, technological, organizational and financial inputs that eventually lead to the implementation of technologically new or improved products and processes. It is important to appreciate that while some of these inputs may be intrinsically innovative, others may not be so.

A technological product innovation concerns the development and commercialization of a product allowing delivery of objectively new or improved performance characteristics to the consumer. Technological product innovation may involve the use of alternative raw materials or new components and could incorporate new design concepts. Technological product innovation can take two broad forms:

(a) Technologically new product: A product whose technological characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge;

Box 13 (*continued*)

(b) Technologically improved product: An existing product, the performance of which has been significantly enhanced or upgraded. A simple product may be improved (in terms of better performance or lower cost) through use of higher performance components or materials, or a complex product which consists of a number of integrated technical subsystems may be improved by partial changes to one of the subsystems.

A technological process innovation is aimed at the development of new or significantly improved production or delivery methods. Technological process innovation may involve changes in equipment, human resources, working methods or a combination of these.

TPP innovation activities are defined as the entire range of scientific, technological, organizational, financial and commercial changes taken with a view to implementing technologically new or improved products or processes. It is essential to note that while some of these changes may be inherently innovative, others may not be so, but are essential for successful implementation.

Technological diffusion is a term used to describe the manner in which technological product and process innovations are disseminated, whether on the basis of market or non-market mechanisms. Diffusion of TPP innovations generally refers to their dissemination from the date of their first implementation to different countries, regions, industrial sectors, markets and firms.

A worldwide TPP innovation is said to occur only the very first time a new or improved product or process is implemented. By contrast, innovation may take place at the firm level each time a new or improved product or process is incorporated by a given innovative firm, despite the fact that the same innovation may have previously been incorporated by other innovative firms, even in other related or unrelated industries.

Source: Adopted from OECD, Oslo Manual, "The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data.", Paris, OECD, 1997.

1. *Factors that influence TPP innovation*

The following factors, affecting TPP innovations, are worthy of further investigation with a view to the design of relevant indicators, promotion of innovative activity at the firm level and ensuring conducive policy frameworks at the national level:

(a) Corporate strategies are instrumental to TPP innovation. Corporate policymakers should be able to appreciate how firms develop their markets and allocate resources to product and process strategies and underlying technologies available to them;

(b) Diffusion of innovative change is the cornerstone of the innovation process. Without diffusion between and within firms, industries and countries, an innovation would, at best, have limited effects. Aspects to be considered in promoting diffusion of TPP innovation include the ability to carry out the carry out the following:

(i) To track the flows of TPP innovation within a given industry and from one industrial segment to another;

(ii) To trace impacts on productivity distinguishing between internal and external sources or destination of the results of the innovating activities;

(iii) To energize inter-firm cooperation via shared R and D, licensing and joint ventures.

(c) Access to sources of information on TPP innovation is of strategic importance. Sources of innovation or technological change may be both internal within an innovative firm, such as residing in its R and D department, or external, emanating from local or international sources of technology;

(d) Obstacles to innovation are many and varied, especially in the case of TPP innovation where skill shortages, missing competencies, and inadequate financial resources directly hinder progress. Attempts should be made to characterize obstacles with regard to the country or sector under question. The perception of obstacles to innovation by firms are also important in their own right and should be similarly subject to assessment;

(e) Measuring inputs to innovation requires an adequate understanding of R and D contributions, such as from universities and publicly funded laboratories, and their importance in industrial applications based on TPP innovations. Non-R and D inputs also contribute significantly to the innovation process. The balance between R and D and non-R and D inputs is valuable information to policy makers;

(f) The role of public policy in industrial innovation cannot be overemphasized. Public policies impact many industrial areas and thus innovation performance, both positively and negatively, especially since the industry incorporates potential for both product and process innovation. Policies that influence education and training affect the amount and level of skills available to produce TPP innovations. Similarly, taxation policies, accounting and industrial regulations, and intellectual property regimes impact the tendency and incentives for innovating;

(g) Innovation outputs carry a number of dimensions, and depend on various factors such as the firm size and technical complexity. It would therefore be useful to consider TPP innovation outputs with regard to both R and D and non-R and D inputs. Due to the variation in innovation outputs, it would also be important to consider industry-specific and country-specific factors that dominate innovation.

2. *TPP innovation activities*

Firms innovate to increase profits. A new technological device could be the source of advantages in efficiency improvement and cost reduction, resulting in lower market price and a subsequently larger market share, thus enabling the innovator firm to increase its profits. A product innovation may also increase the market share of the firm by creating a monopoly situation (either through a patent or time gained before competitors have developed a similar product) that enables it to set higher market prices and command higher profits.

Competitive positioning may also be an important result of innovation. Thus, firms may innovate to maintain or enhance their competitive advantage. Firms may take a reactive approach to prevent the loss of market share to an innovative competitor. Alternatively, they may take a proactive approach through opting for innovation to gain a strategic market position.

Innovations ultimately spread from their first locus of implementation to different countries, regions and industries through processes known as technological diffusion. The diffusion of technologies may be a very lengthy process involving continuous and incremental improvement diffused technologies.

C. INNOVATION NETWORKS

Innovation often involves the collaboration of several organizations, as evidenced in the increase in cooperative agreements over the past few decades, witnessed especially in some of the most valuable, knowledge-intensive areas of industrial activity, particularly where reliance on complex technologies is essential.[37]

[37] N. Vonortas, “Science, Technology, and Innovation Indicators”, George Washington University, USA, 2002.

Cooperative agreements enable several benefits, such as helping firms to adapt to environments of risk and competition, in addition to assisting in the generation and diffusion of knowledge. Cooperation may involve activities, including the following:[38]

(a) Exchange of students and researchers;
(b) Joint research projects sharing common objectives;
(c) Joint scientific meetings;
(d) Information sharing without necessary movement of people;
(e) Mutual access to national activities;
(f) Joint development of science infrastructure.

Similarly, innovation networks involve a wide range of activities such as joint production and marketing ventures, joint R and D, and technology exchange agreements.[39] Terms such as "strategic alliance" and "strategic partnership" are often used to describe the main building blocks of innovation networks. These networks bring together a number of actors, such as large industrial firms, small and medium enterprises, universities, and government agencies, with a common goal of producing innovations. An emerging concept that resonates with the idea of networking and knowledge sharing is the "Community of Practice" (CoP), a group of people, with an array of disciplinary backgrounds, working towards a common purpose while learning from each other's experiences.[40]

Box 14. A community of practice: the Environment and Sustainable Development Unit at the American University of Beirut

In 2001, the Faculty of Agriculture and Food Sciences at the American University of Beirut (AUB) established the Environment and Sustainable Development Unit (ESDU) to "promote collaboration on sustainable development initiatives among departments at AUB and a wide variety of other institutions and organizations undertaking related activities". It was established on the basis of the pressing need to address environment and sustainable development issues in an integrated multidisciplinary approach in order to generate sound solutions. The ESDU emphasizes the need for action-oriented, policy-relevant and participatory research and development activities, which are highly necessary for community development.

The primary goal of ESDU is to advance AUB as a regional leader in sustainable development initiatives, and to build a strong body of faculty and student researchers from many different disciplines. The ESDU aims to establish strategic partnerships with private and public sectors, and network with national, regional and international research centres concerned with community development in the light of natural resource management and sustainable development. Research projects that ESDU is involved in vary from urban and rural ecological change, to biodiversity and wastewater treatment.

Source: Environment and Sustainable Development Unit (ESDU), American University of Beirut, 2001. Available at: http://people.aub.edu.lb/~webeco/ESDU/index.html.

However, there is a critical lack of systematic data and indicators to inform analysts about the nature, dynamics and success factors of innovation networks. Due to the complex and multi-level structure of these networks, major efforts are needed in the development of informative and comprehensive indicators.

[38] Community Research and Development Information Service (CORDIS). "Bilateral International R and D Cooperation Policies in the EU Member States". INDINEWS Newsletter on Science and Technology and Innovation Indicators, No. 6, June 2002.

[39] N. Vonortas, "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

[40] Community Intelligence Labs, "What is a 'Community of Practice'?", 2000. Available at: http://www.co-i-l.com/coil/knowledge-garden/cop/definitions.shtml.

There are currently two large research projects in progress for the development of indicators and methodologies for gathering data on innovation networks, one in the United States[41] and another in the EU.[42] Although both projects gather data using the subject approach, the actual data collected is both subject and object based.

The primary unit of analysis in the two projects is the organization. Each project is developing large databanks to store the collected data, allowing empirical analysis of the types of networks and their evolution.

Network indicators under development so far examine the extent of strategic alliances, patents and patent citations, scientific publication and citations (bibliometrics), and research and technology partnerships. In combination with other data, namely from innovation surveys, data collected on innovation networks will allow important policy questions to be considered,[43] including:

(a) The extent of evolution of innovation networks from national, or regional, to global, providing implications of technology transfer, intellectual property protection, competition, and regional development;

(b) Competitiveness in knowledge-intensive sectors taken on the basis of networks of companies rather than taking them individually;

(c) Incentives and evaluation criteria set forth by governments in promoting new technologies in order to achieve the most effective network structures;

(d) Formation of public-private networks in specific sectors or technologies.

Network indicators account for the complex relationships among involved innovating agents, and thereby fill the gap of other traditional input and output indicators by helping to understand the innovation process.

Box 15. ESCWA initiatives towards networking in innovation

In its continuous efforts to promote innovation networks, ESCWA launched two initiatives: ESCWA Research and Development Portal (ERDP) and the Network of Technology Parks and Technology Incubators (NTPI). Both portals discuss plans and achievements in ESCWA member countries.

The ERDP is "intended to promote collaboration among individuals and institutions throughout the region involved in Research and Development (R and D)". The portal intends to generate more R and D cooperation among ESCWA member countries, and aims at adaptation and development of new knowledge and Environmentally Sound Technologies. The main topics supported in the portal relate to manufacturing, industry, and Information and Communication Technology. The ERDP lists institutions, publications and events related to R and D.

Sustainable development in ESCWA and Arab countries is dependent on acquiring a wide range of technologies in the production and services sectors. The Network of Technology Parks and Technology Incubators (NTPI) discusses ESCWA initiatives in technology parks, incubator schemes and high technology manufacturing and service clusters that integrate a number of new concepts in technological capacity building. The Technology Parks contain, in the same place, facilities that include R and D, manufacturing, high-level training, technology and business incubation, financing institutions, standardization and calibration laboratories, testing and analytical facilities, industrial services and facilities. ESCWA was approached by some member countries for designs of these parks whereas other member countries such as Bahrain, Jordan and the United Arab Emirates already established some technology parks. The NTPI gives full details about the Technology Parks in each ESCWA member country.

Source: ESCWA, Research and Development Portal. Available at: http://db.escwa.org.lb/erdp/index.asp. Network of Technology and Technology Incubators. Available at: http://escwa.org.lb/ntpi.

[41] At the Center for International Science and Technology policy, George Washington University. Available at: http://www.gwu.edu/~cistp/PAGES/indicators2.html.

[42] Launched by the European Community Research and Development Information Service (CORDIS). Available at: http://www.stinet.org.

[43] N. Vonortas, "Science, Technology, and Innovation Indicators", George Washington University, USA, 2002.

D. CONCLUDING REMARKS

To this day, experts have been attempting to demystify the multidimensional and complex concept of innovation. Earlier views depicted innovation as a linear process, from conception to actual application. Later, views expanded this definition to include various other factors, such as process innovation, networking, and effective knowledge sharing.

Several dynamics promote and inhibit innovation. Typically, the principal objective of enterprises was to be more productive and more competitive, which calls for further investment, to be properly equipped with skilled personnel, ICT infrastructure, and so on.

Innovation can take place at any level and in any sector of the economy, and need not necessarily incorporate intensive R and D activity. In light of this, networks of research professionals, students, institutions, enterprises, and so on, have been formed and given the name Innovation Networks. Such networks are helping promote the movement of knowledge across levels and sectors, and highlight the fact that both R and D and non-R and D inputs play a role in innovation.

Indeed, the intricacy of the innovation process makes it all the more complex to measure. Major attempts to produce standardized innovation indicators and methodologies for their measurement have been conducted by the OECD in the Oslo Manual and through Community Innovation Surveys. The chapter has provided a brief analysis of the findings of the surveys, in addition to describing two methods for collecting innovation data, the object and subject-based approaches.

The Oslo Manual stressed particularly on TPP innovations, which involve a variety of activities on a scientific, technological, organizational, and financial front, leading eventually to technologically new or improved products and processes.

Innovation activity must not only be promoted for the wider goal of increasing enterprise competitiveness and productivity, but must be extended to help eliminate gender discrimination, illiteracy, and lack of proper schooling as well. One possible solution, which is currently a major initiative being undertaken by ESCWA, is to establish community centres in rural areas in order to provide local communities with the benefits of technology. This requires innovative solutions incorporating ICTs to introduce new opportunities to the rural communities.

IV. INFORMATION, COMMUNICATION AND TECHNOLOGY INDICATORS

A. THE NETWORKED WORLD

ICTs have considerably contributed to the social and economic development of countries striving to catch the tide of the global knowledge-based economy. The networked world holds profound challenges and opportunities with a wide range of socio-economic and cultural dimensions. Investing in ICT infrastructure will allow developing countries to integrate and enhance their prospects in the global economy. However, along with promises for economic prosperity comes the responsibility to recognize new challenges that ICTs bring, especially for developing countries.

The immense socio-economic implications of ICTs have prompted many development organizations to establish methods for assessing efforts in ICT capacity building. Developing a systematic approach for the collection of ICT data will no doubt enrich the decision-making process by revealing areas of weakness and strength. Developing countries must particularly acknowledge the need to benchmark themselves against the rest of the world. The lack of meaningful data on ICT capacity building adds to concerns about future performance.

The current state of ICT capabilities in ESCWA member countries and Arab countries leaves much to be desired. As a result, ESCWA is currently undertaking the initiative to develop a comprehensive database of S and T indicators including ICT indicators for its member countries. This will add support to policy-making and decision-making. A list of selected S and T and ICT indicators, together with their definitions, earmarked for inclusion in this database, is presented in annexes I and II.

B. SELECTED ICT INDICATORS

The World Bank defines ICTs as "the set of activities which facilitate by electronic means the processing, transmission and display of information".[44] By improving communication, ICTs promote information sharing and the accumulation of knowledge, and are essential in organizing and restructuring working methods. However, there are barriers that hinder the effective diffusion and implementation of ICTs in many countries, such as general and computer illiteracy. The uneven diffusion of technology, which includes even conventional telephony, marks a failure in the developing world to participate in the new digital world.[45]

ICT indicators discussed in this section include personal computers, fixed telephone lines, cellular subscribers, Internet hosts and Internet access. The Networked Readiness Index (NRI), a recently developed composite indicator, and indicators relating to ICTs in education are also briefly considered. According to the United Nations Conference on Trade and Development (UNCTAD), national ICT capacity can be categorized as follows: connectivity, access, policy and usage.

Indicators allow for comparison of ICT capacity building between countries in reference to defined criteria allowing decision and policy makers to devise appropriate policies and future action plans. However, in order to fully appreciate the significance of certain indicators, it is necessary to consider a number of related social and economic parameters, since the value of an indicator does not always relate to socio-economic conditions and can seldom be used in isolation from underlying conditions that may facilitate or constrain ICT utilization. Nevertheless, an important starting point is to collect data on indicators at the national level as a prelude to their analysis in relation to socio-economic and other factors. Data on indicators discussed in the present section are included for illustrative purposes.

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[44] UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003. (UNCTAD/ITE/IPC/2003/1).

[45] Ibid.

Several recent attempts at crafting measures of ICT capacity that are sensitive to specific socio-economic and national situations will need to be considered in more detail when devising a set of indicators, both simple and composite, that relate as closely as possible to current conditions in ESCWA member countries, and indeed for the Arab region as a whole. The following paragraphs provide a very brief outline of recent attempts by UNCTAD at devising such systems of indices.

The details of these UNCTAD ICT indicators are shown in table 13. In effect, the indicators discussed in the present section are a subset of the UNCTAD indicators. Connectivity indicators, namely personal computers, fixed telephone lines, mobile phone lines and Internet hosts, and one access indicator, namely Internet usage, are included. The rest of the access indicators are briefly discussed with examples from selected ESCWA countries. A selection of policy indicators are also briefly explained with information on policy issues in certain ESCWA countries. The usage index depends on both incoming and outgoing data and voice traffic, and since there is a lack of reliable Internet traffic data, the only remaining usage indicator is telephone traffic data. However, telephone traffic alone does not sufficiently represent the usage index, in spite of its reliability. Due to the aforementioned shortcomings, UNCTAD has excluded the usage index from its study of connectivity.

TABLE 13. CONSTRUCTION OF THE ICT DEVELOPMENT INDICES

Index/dimension	Indicators	Sources
1. Connectivity	Internet hosts per capita Number of PCs per capita Telephone mainlines per capita Cellular subscribers per capita	ITU
2. Access	Internet users per capita Literacy (population percentage) GDP per capita Cost of local call	ITU UNSD World Bank ITU
3. Policy	Presence of Internet exchange Competition in local loop telecom Competition in domestic long-distance Competition in Internet Service Provider (ISP) market	UNCTAD research ITU ITU
Usage: Telecom traffic	International incoming traffic International outgoing telecom traffic	ITU ITU

Source: UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003 (UNCTAD/ITE/ICP/2003/1).

Organizations such as Harvard University and the International Telecommunications Union (ITU) have also adopted the same main categories as UNCTAD, namely, connectivity, access, policy, and usage, except with slightly different perspectives and different measurement methods for each category. The ITU, for instance, measures the indicators from a telecom perspective. Statistics presented in this study have been adapted from ITU statistics. On the other hand, sociological conditions are taken into consideration when calculating values for the indices by the Harvard University. The Networked Readiness Index, adopted by Harvard, is briefly discussed in this study. It is noteworthy that there are studies carried out by other organizations such as the Economist Intelligence Unit (EIU) and McConnell International which are focused on indicators more closely related to commercial implementation of ICTs. Table 14 provides an outline of measurement methods and perspectives by all the aforementioned organizations.

Establishing a set of simple and composite indicators, or indices, in order to measure capacity building, is a task that must be tackled collectively by several regional and international organizations on the basis of national profile studies. The World Summit on the Information Society (WSIS) and related preparative activities should constitute valuable opportunities for such an endeavour.

TABLE 14. THEORETICAL FRAMEWORK FOR MEASURING ICT DEVELOPMENT

Index	UNCTAD	McConnell International (2001, 2002)	Economist EIU (2001, 2001)	Harvard University Guidelines (2000)	ITU (2001)
Perspective	Technological development	Commercial	Commercial	Sociological	Telecoms
Item measured	ICT development	E-readiness	E-readiness	Networked Readiness	Internet access
1. Connectivity (physical, capacity, infrastructure)	Internet hosts; telephone mainlines; PCs; mobile subscribers	Connectivity; infrastructure pricing	Connectivity (30 per cent) fixed and mobile, narrowband/ broadband	Information infrastructure; software and hardware	Hosts; servers; telephones; PCs
2. Access (wider determinants of access)	Internet users; literacy; average revenue; call costs	Access	Cost of access; availability; affordability	Availability, affordability	Users; subscribers
3. Policy environment	Competition: local loop, long distance, ISP markets; Internet exchange	E-leadership; E-business climate	Legal and regulatory environment (15 per cent) Business environment (20 per cent)	Legal environment: Telecom and trade policy	ISPs; prices; traffic
4. Usage	Telecom traffic: incoming, outgoing	Information security	E-commerce (20 per cent) consumer/business use; E-services (10 per cent)	Content B2B; education B2C; E-commerce	
Other		Human capital	Social and cultural infrastructure (5 per cent) Education/literacy	IT sector; ICT training	

Source: UNCTAD, *Information and Communication Technology Development Indices, 2003* (UNCTAD/ITE/ICP/2003/1).

1. *Telephony*

One of the most traditional and widely used measures of ICT infrastructure is the growth of the telecommunication network, since it provides a basic foundation for other networks such as those related to data communication.[46] Two telecommunication indicators are discussed here, namely the density of main telephone lines and of mobile subscribers, which are both comprehensively reported by the ITU.

(a) *Main Telephone Lines*

The connection between a customer's equipment, such as a telephone set, and a dedicated port on the Public Switched Telephone Network (PSTN) is referred to as a main telephone line.[47] The number of main telephone lines is "a relatively reliable, basic limiting factor of connectivity and representative of potential"[48]

[46] Science and Technology Policy Research Unit (SPRU). *Knowledge Societies – Information Technology for Sustainable Development*. Edited by Mansell, R. and Wehn, U. Oxford University Press. 1998.

[47] International Telecommunication Union (ITU), "Arab States Telecommunication Indicators", 2000. Available at: http://www.itu.int/ ITU-D/ict/statistics/at_glance/ARTI00_E.pdf.

[48] UNCTAD, *Information and Communication Technology Development Indices 2003*, New York and Geneva, p. 11. (UNCTAD/ITE/IPC/2003/1).

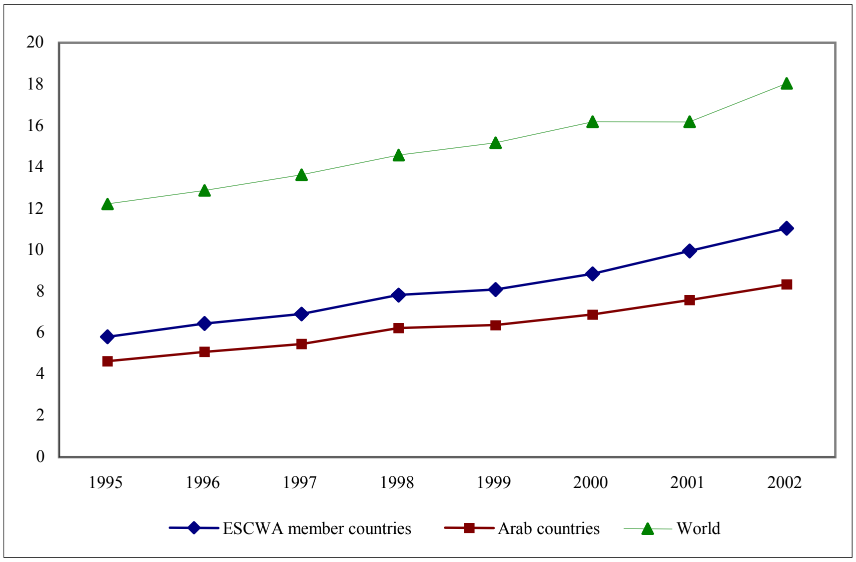
for networking citizens, institutions and enterprises among one another and with the world at large. Clearly, as the number of telephone lines increases, Internet usage should theoretically increase given Dial-Up connection availability and acceptable costs. Other factors that play a role in determining the overall connectivity of a country could include national income, population distribution, and geographical factors.[49] Box 16 provides statistics on the number of fixed telephone lines in ESCWA member countries.

Box 16. Main telephone lines in ESCWA member countries

According to data compiled from the ITU, Arab countries lag far behind world averages in main telephone line densities. While the world average main telephone line density was around 18 per hundred inhabitants in 2002, that in the Arab countries was approximately half of this figure, and 11 in ESCWA member countries alone (see figure 15). In some of the poorer Arab countries, namely Yemen, where there were only 2.24 main telephone lines per 100 inhabitants in 2002, telephone facilities, and hence internet connectivity, are indeed a privilege.

The United Arab Emirates had the highest main telephone line density in ESCWA region in 2002, at 34.2 main telephone lines per 100 inhabitants. In fact, Bahrain, Kuwait, Qatar and the United Arab Emirates are the largest contributors towards the growth seen in the region, especially in the countries of the Gulf Cooperation Council (GCC) where the main telephone line density far exceeds that of the world. However, despite significant investments in upgrading main telephone lines in the region, convergence of growth patterns in the Arab countries and the world as a whole over the last several years requires serious efforts in infrastructure development.

Figure 15. Main telephone lines per 100 inhabitants in ESCWA and Arab regions compared with the world



Sources: Adapted from ITU, World Telecommunication Indicators Database, 6th edition, 2002; and ITU, Arab States Telecommunication Indicators, 2000.

[49] UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003 (UNCTAD/ITE/IPC/2003/1).

(b) *Mobile subscribers*

The indicator for mobile telephone subscribers refers to the number of users of portable telephones subscribed to an automatic public mobile telephone service that provides access to PSTN based on either digital or analogue cellular technology.[50]

Throughout the world, the mobile telephony sector has grown by leaps and bounds over the years. The mobile telecommunications sector in ESCWA region is largely based on second-generation networks of the Global System for Mobile Communications (GSM). In the early stages of the GSM network, mobile services were limited to secure voice and data transmission, such as text messages, in addition to full roaming features.[51] Recently, new services were introduced that enhanced mobile telecommunications such as the General Packet Radio Service (GPRS). GPRS provides continuous Internet capabilities, multimedia messages, and location-based services and is now available in several ESCWA member countries such as Jordan, Kuwait, Lebanon, and the United Arab Emirates.[52] Acquiring GPRS in some ESCWA member countries is a promising step toward third generation, or "3G", GSM technology. Another globally evolving technology is EDGE, which stands for Enhanced Data Rates for GSM Evolution. EDGE delivers advanced mobile services that comprise downloading video and music clips, multimedia messaging, high-speed colour Internet and e-mail.[53] It also enables current GSM networks to accommodate third generation GSM networks. While introducing EDGE technology in Kuwait is planned,[54] this service is still not available in any of the ESCWA member countries.

Although GSM networks are the most popular among mobile telecommunication networks, satellite telephony also exits in the ESCWA region and the Arab world through the Thuraya Satellite Telecommunications Company. The Thuraya satellite covers the Middle East, North Africa, part of Europe and South Asia, and provides both satellite and GSM capabilities.

Box 17. Mobile telephony in ESCWA member countries

According to ITU data, by the end of 2002, there were over 21 million mobile telephone subscribers in the Arab region, using the mobile telephone mainly for voice communications, business and entertainment. However, the use of the mobile telephone in these countries is still heavily biased towards mere voice messaging. Integration of mobile communication into commercial enterprise activities is still poor compared to that in developed countries. One way governments could play a role in promoting the use of telecommunications in businesses is by improving service quality and lowering charges, and by allowing competition in countries presently with a sole telecommunications operator.

Figure 16 shows that ESCWA member countries are behind world averages in the density of cellular subscriptions. In 2002, the number of mobile subscribers in the ESCWA region was around 9.4 per 100 inhabitants, lagging behind the world average of 13 per 100 inhabitants by 28 per cent. Nonetheless, the mobile sector has advanced faster than the fixed telephones sector in ESCWA member countries who lag behind world countries by 39 per cent in the number of fixed telephone lines.

[50] International Telecommunication Union (ITU), "Arab States Telecommunication Indicators", 2000. Available at: http://www.itu.int/ ITU-D/ict/statistics/at_glance/ARTI00_E.pdf.

[51] GSM World, "Today's GSM Platform", 2003. Available at: http://www.gsmworld.com/technology/gsm.shtml.

[52] GSM World, "GPRS operators", 2003. Available at: http://www.gsmworld.com/technology/gprs/operators.shtml.

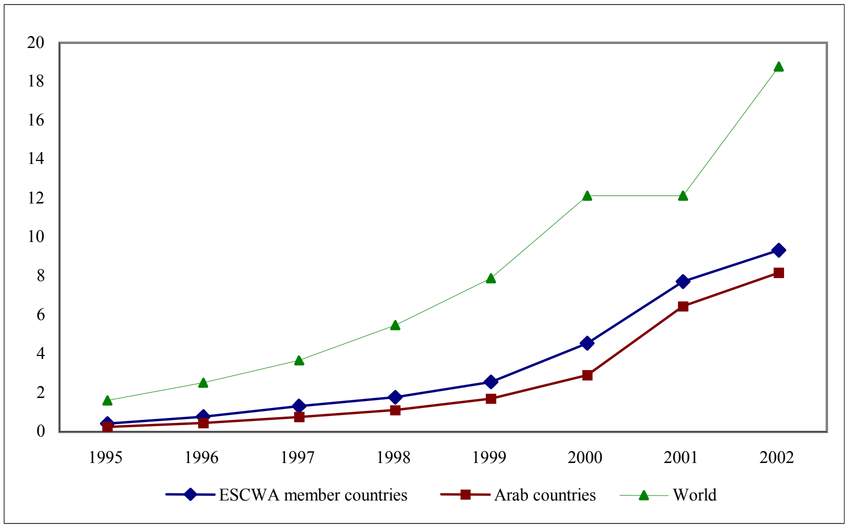
[53] GSM World, "EDGE Platform", 2003. Available at: http://www.gsmworld.com/technology/edge/index.shtml.

[54] GSM World, "EDGE Operators", 2003. Available at: http://www.gsmworld.com/technology/edge/operators.shtml.

Box 17 (*continued*)

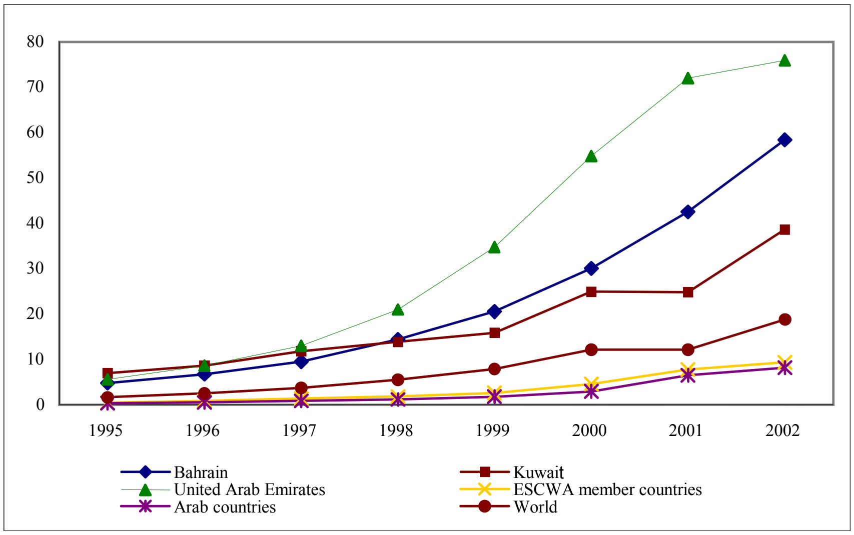
A closer look shows that the United Arab Emirates is the largest contributor among ESCWA member countries with an average of 76 mobile telephones per 100 inhabitants in 2002. Moreover, Bahrain, Kuwait, and Qatar have contributed most significantly to the growth of mobile telephony in ESCWA member countries and the Arab countries during the 1995-2002 period (see figure 17). Increasing the investment in mobile telephony is necessary in some countries including Egypt, Syrian Arab Republic and Yemen, which have very low mobile subscribers density as compared to other ESCWA member countries, Arab countries, and the world in general.

Figure 16. Mobile telephone lines per 100 inhabitants in ESCWA and Arab regions compared with the world



Sources: Adapted from ITU, World Telecommunication Indicators Database, 6th edition, 2002; and ITU, Arab States Telecommunication Indicators, 2000.

Figure 17. Mobile telephone lines per 100 inhabitants in selected Arab countries



Sources: Adapted from ITU, World Telecommunication Indicators Database, 6th edition, 2002; and ITU, Arab States Telecommunication Indicators, 2000.

2. *Personal computers*

The number of personal computers (PCs) available to a given population could provide a measure of its ability to join the global economy and enhance productivity. At any rate, PC density is a major precondition for Internet connectivity. This is especially the case in ESCWA member countries where handheld devices are still not widely available.

Data on the number of PC users available is not completely reliable. Statistics are largely based on PC imports, while other sources such as local assembly are ignored. The indicator also lacks the qualitative description of PCs, including the quality and power of PCs in actual use.[55]

Hundreds of millions of people worldwide now depend on personal computers in several aspects of their daily lives. In ESCWA member countries, some governments, schools, hospitals and even small enterprises still use PCs for a rather narrow range of applications, namely, word processing, accounting, Internet browsing and messaging. Around 80 per cent of small and medium enterprises (SMEs) in Jordan are reported to use PCs in their daily tasks.[56] For obvious reasons, Iraq suffers a lack of computer technology infrastructure in spite of the availability of skilled IT manpower. Plans by international agencies and enterprises are underway to help rebuild this country's IT infrastructure.[57] Box 18 provides an overview of the number of personal computers in ESCWA member countries.

Box 18. Number of personal computers in the ESCWA member countries

Between 1995 and 2002, the world witnessed a steep rise in the density of personal computers (PCs). The gap between the growth rates of the average number of PCs per 100 inhabitants in ESCWA member countries and the world is not only large but also appears to be widening (see figure 18). Although the average number of PCs in ESCWA member countries is higher than that of Arab countries, it is till far behind world PC density and trends also appear to be diverging here. In 2002, the average PC density in ESCWA member countries was only 2.94 per 100 inhabitants, which was only about one third of the world's average, 9.4 per 100 inhabitants. A closer look reveals that GCC countries are the main contributors to PC density in the ESCWA region and the Arab countries, in general.

A significant increase in average PC density has been witnessed in some Arab countries, including Bahrain, Kuwait, Qatar, and United Arab Emirates, now surpassing world densities. In fact, even despite a 15 per cent decrease in PC density in 2002, the United Arab Emirates still exceeded the world's average PC density by more than 4 PCs per 100 inhabitants. Kuwait witnessed a steady increase in PC density from 1995 to 2000 followed by a sharp peak in 2001. Qatar, with 18 PCs per 100 inhabitants in 2002, had the highest density compared to other Arab countries and the world that year.

The density of PCs in Lebanon gradually increased from 1.7 PCs per 100 inhabitants in 1995, to almost 8 PCs per 100 inhabitants in 2002, which exceeds that of the non-GCC countries, at 1.4 PCs per 100 inhabitants and is close to the world average. Lebanon also had a higher growth rate of PC density than any country in both the Arab and ESCWA regions (see figure 19).

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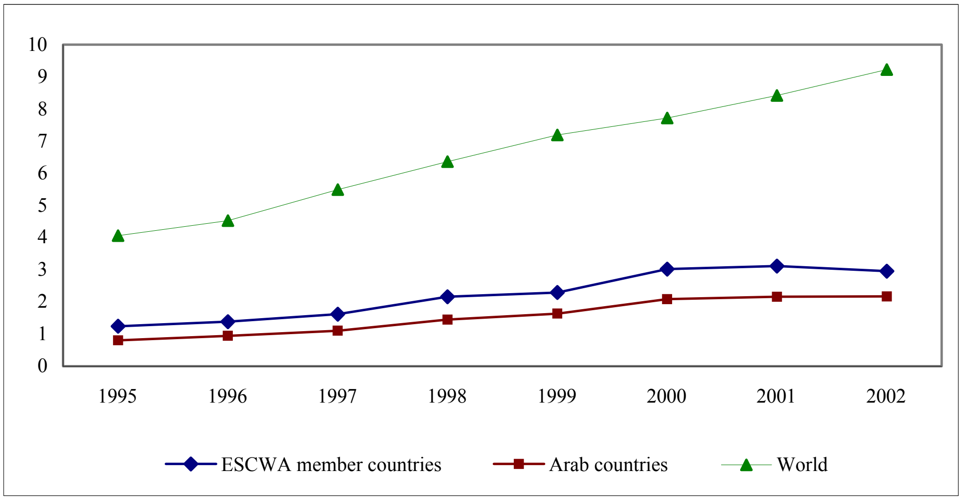
[55] UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003. (UNCTAD/ITE/IPC/2003/1).

[56] AME Info, "Arab Advisors Group reveals 78 per cent of Jordanian SMEs utilize computers", February 24, 2003. Available at: http://www.ameinfo.com/news/Detailed/19197.html.

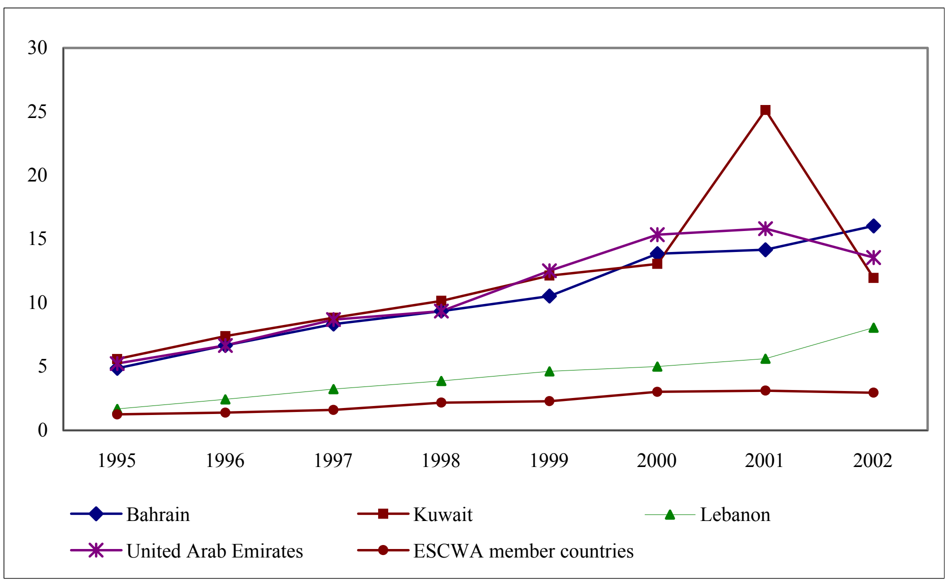
[57] AME Info, "APTEC takes up the challenge of helping rebuild IT infrastructure in Iraq", May 21, 2003. Available at: http://www.ameinfo.com/news/Detailed/24196.html.

Figure 18. Personal computers per 100 inhabitants in ESCWA and Arab regions compared with the world



Sources: Adapted from ITU, World Telecommunication Indicators Database, 6th edition, 2002; and ITU, Arab States Telecommunication Indicators, 2000.

Figure 19. Personal computers per 100 inhabitants in selected ESCWA member countries



Sources: Adapted from ITU, World Telecommunication Indicators Database, 6th edition, 2002; and ITU, Arab States Telecommunication Indicators, 2000.

3. *Internet access*

Internet access comes as a result of the availability of computers and Internet connection means, including telephone lines and wireless connections. Several indicators may be used to measure the extent of Internet use, although the two indicators currently used the most are the number of subscribers and the

number of users. The former is considered by ITU to be a more precise measure than the latter because it indicates the number of those who pay for Internet access. However, this indicator may have shortcomings since it ignores free or shared access.[58]

The most widely used Internet access means is Dial-Up, where users are provided accounts by Internet Service Providers (ISPs). Consequently, the cost of accessing the Internet will depend on the cost of a local telephone call and the cost of subscribing to an ISP. In countries where these costs are high, Internet access is limited. The per capita Gross Domestic Product (GDP) of a country provides implications towards the extent of Internet use, as well as a country's development and ICT investment level.[59] Table 15 shows the per capita GDP in ESCWA member countries. Other barriers to Internet access in ESCWA member countries include illiteracy and language differences. In 1990, 80 per cent of the web pages were in English, imposing a large barrier to all non-English speaking persons. Recent statistics, dated 2003, show that 68 per cent of web content is in English[60] compared to a mere 0.1 per cent of Arabic web content.[61]

TABLE 15. GDP PER CAPITA IN ESCWA MEMBER COUNTRIES

Country	GDP per capita
Bahrain	13 111
Egypt	3 041
Iraq	3 197
Jordan	3 347
Kuwait	25 314
Lebanon	4 326
Oman	9 960
Palestine	-
Qatar	20 987
Saudi Arabia	10 158
Syrian Arab Republic	2 892
United Arab Emirates	17 719
Yemen	719

Source: UNDP, *Arab Human Development Report 2002*: Creating Opportunities for Future Generations. Jordan, 2002.

Despite hindrances to Internet access, reasons for using the Internet are increasing by the day. Several enterprises in ESCWA member countries are transferring their interactions to the Internet. The Web is emerging as a powerful and relatively cheap marketing medium for advertising agencies. Thousands of people in ESCWA member countries access the Internet daily for various purposes including research, communication, business dealing or simply for entertainment. The majority of these Internet users employ desktop computers and only a few use handheld devices such as GPRS mobile phones and Personal Digital Assistants (PDAs), which have high future prospects.

Services currently provided by ISPs in ESCWA member countries include mainly Dial-Up access. With the exception of the United Arab Emirates, ISPs in ESCWA member countries still lack high-value services such as broadband, and if available they are usually reserved for corporate clients only.[62] For

[58] UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003 (UNCTAD/ITE/IPC/2003/1).

[59] Ibid.

[60] Ibid.

[61] Madar Research, "Arabic web content on an uphill course", 2002. Available at: http://www.madarresearch.com/journal/infocusdetail.aspx?infocusid=9.

[62] World Economic Forum. Edited by S. Dutta, B. Lanvin, and F. Paua, *The Global Information Technology Report 2002-2003. Readiness for the Networked World*. Oxford.

instance, the Dubai Internet City in the United Arab Emirates is one of the very few places that offer 2Mbps broadband connection for each of its business partners via a 10/100 Mbps Ethernet connection.[63] There are promising plans in many ESCWA member countries to improve Internet access but currently they are far behind the Internet status in developed countries.

Box 19. Internet access and applications in ESCWA member countries

Emerging Internet applications in ESCWA member countries include e-learning and e-government. The United Nations ranked the United Arab Emirates as the first among ESCWA member countries to successfully deploy e-government.[a/] Meanwhile, the field of e-learning is slowly growing in ESCWA member countries, and is still experiencing a shortage in Arabic educational online applications. Tejari.com and Sakhr are examples of companies that introduced Arabic e-learning solutions in 2002, the former offering business-oriented courses,[b/] and the latter bilingual solutions for web portals.

E-commerce is an evolving medium in ESCWA member countries, particularly business-to-business (B2B) e-commerce, which involves two or more companies selling and buying goods and services over the Internet. Tejari.com is an example of a B2B company. Based in Dubai, Tejari provides a platform for many companies to buy or sell products using online catalogues. Business-to-customer (B2C) e-commerce is not blooming as much as B2B is in ESCWA member countries because it highly depends on penetration rates and confidence in online security of users.[c/]

Based on ITU data, Internet usage in the world has grown steadily between 1999 and 2002. There were around 10 internet users per 100 inhabitants in the world as opposed to 4 in 1999. Internet users in ESCWA member countries and the Arab countries are increasing rather slowly and are far behind world averages. In 2002, the number of Internet users in the ESCWA member countries was 3.2 per 100 inhabitants, which was about one third of the world's average. Figure 20 shows the number of Internet users per 100 inhabitants in the world and selected Arab countries and regions for 2002. The United Arab Emirates witnessed the highest Internet usage among Arab countries with almost 37 Internet users per 100 inhabitants. Other significant contributors to Internet usage in the Arab world include Bahrain, Kuwait, Lebanon and Saudi Arabia. In fact, Internet usage in Lebanon and Bahrain exceeded the world average in 2002, at 24.7 and 11.7 Internet users per 100 inhabitants, respectively. On the other hand, other Arab countries such as Yemen and the Syrian Arab Republic exhibited very low Internet penetration, most likely due to low income, high call charges, and restrictive government policies with regard to ISPs.

a/ AME Info, "UN benchmarking index lists UAE among top achievers in e-government globally", 11 September 2002. Available at: http://www.ameinfo.com/news/Detailed/10269.html.

b/ AME Info, "Tejari.com's members to benefit from new e-learning initiative", 2 May 2002. Available at: http://www.ameinfo.com/news/Detailed/15232.html.

c/ AME Info, "The New Wired World", 19 June 2001. Available at: http://www.ameinfo.com/news/Detailed/16646.html.

4. *Internet hosts*

A host is "a domain name that has an Internet Protocol (IP) address record associated with it".[64] Domain names are alphanumeric identifiers used to refer to computers connected to the Internet.[65] The number of Internet hosts reflects the extent of a country's presence on the Internet. Yet, ambiguity and difficulty emerge when correlating Internet addresses to a country because a top-level domain name does not necessarily correspond to a certain country. To illustrate, the ".us" top-level domain name does not assure

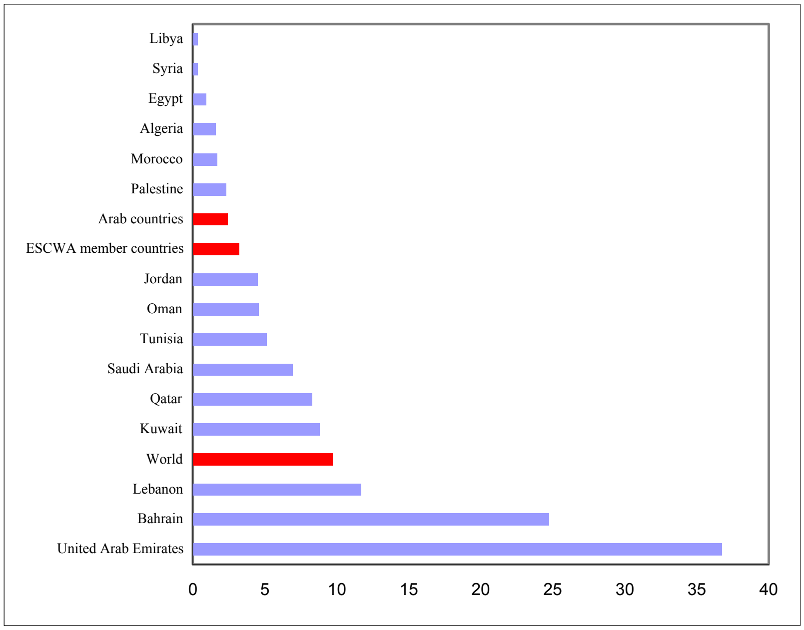
[63] Dubai Internet City, Internet access services, 2002. Available at: http://www.dubaiinternetcity.com/html/internetservice.htm.

[64] Minges, M. "Counting the Net: Internet access indicators." 10th Annual INET Conference-Internet Society, Japan, July 18-21, 2000. Available at: http://www.isoc.org/inet2000/cdproceedings/8e/8e_1.htm.

[65] Living Internet, "Domain Names", 2002. Available at: http://livinginternet.com/?i/iw_dns_name.htm.

that the corresponding host is in the United States. Moreover, many domain names do not indicate the country in which they are present and frequently end with ".com" or ".net".[66]

Figure 20. Internet usage per 100 inhabitants in selected countries and regions 2002



Box 20. Internet hosts in ESCWA member countries

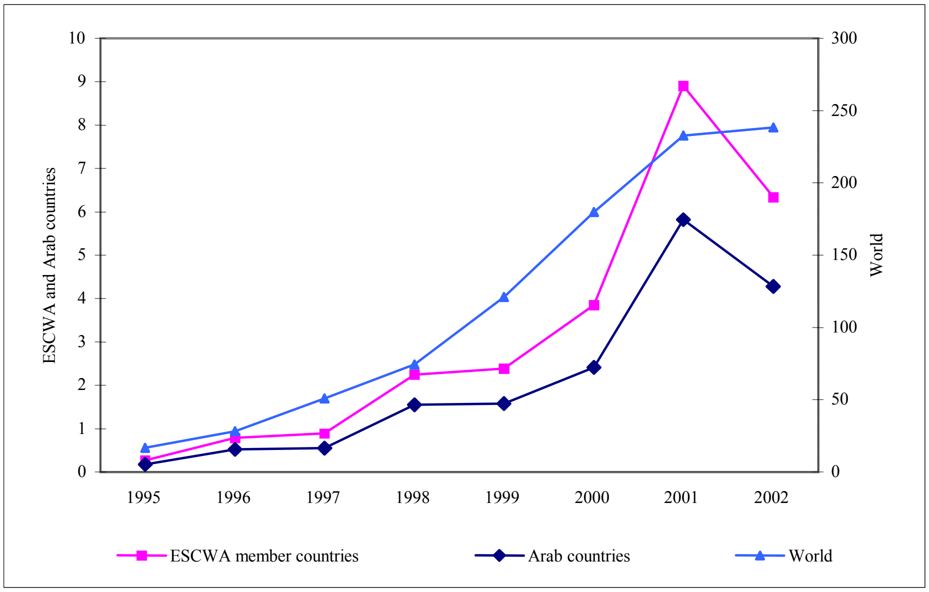
Statistics reveal that the number of Internet hosts per 10,000 inhabitants in the world rapidly grew from an average of 16.7 in 1995 to about 233 in 2001. ESCWA member countries are still very far behind such averages as can be seen in figure 21. Internet host densities in the Arab world constitute a small fraction of the World's average host density.

GCC countries contributed to the rate of growth in Internet hosts in ESCWA member countries more than non-GCC countries. There were a total of 24 Internet hosts per 10,000 inhabitants in the GCC countries in 2002. More specifically, the growth rate witnessed in the GCC countries is largely attributed to the United Arab Emirates, in which there were 163.6 Internet hosts per 10,000 inhabitants in 2002 (see figure 22). On the other hand, Lebanon had the largest density of Internet hosts among non-GCC countries in 2002 with around 21 per 10,000 inhabitants.

Source: Adapted from ITU World Telecommunication Indicators Database, 6th edition, 2002.

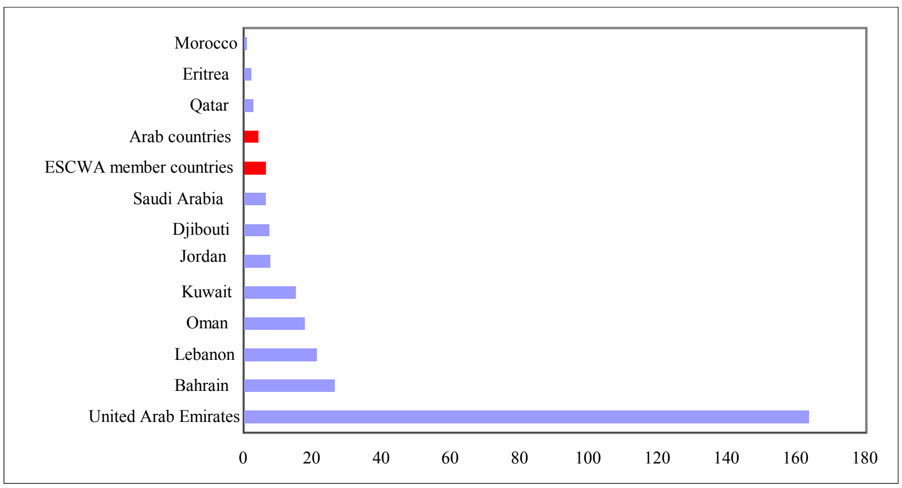
[66] UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003 (UNCTAD/ITE/IPC/2003/1).

Figure 21. Internet hosts per 10,000 inhabitants in ESCWA and Arab regions compared with the world



Source: Adapted from ITU World Telecommunication Indicators Database, 6th edition, 2002.

Figure 22. Internet hosts per 10,000 inhabitants in selected Arab countries and regions, 2002



Source: Adapted from ITU World Telecommunication Indicators Database, 6th edition, 2002.

5. *Policy*

The Policy index, defined by UNCTAD, encompasses three indicators, namely, the presence of Internet exchanges, competition in local fixed telephony, and competition in the ISP market. The value of the index is then taken as the simple average of these three indicators.

(a) *Presence of Internet Exchanges*

An Internet Exchange (IX) is defined as "a physical installation created by third parties to facilitate traffic exchange between ISPs".[67] It is also defined as the "services created to facilitate on-site interconnections between independent or third party Internet networks".[68] The latter definition has lead to ambiguity concerning countries that have access to functions of an IX and those that actually possess one. Consequently, information from ITU and from other sources may not always correspond exactly.

Internet Exchanges are also called Network Access Points (NAPs) or Metropolitan Area Exchanges (MAEs). When a country acquires its own IX, it enhances the local Internet infrastructure and allows exchange of information inside its borders without the need to use international bandwidth. Hence, the importance of implementing a policy that establishes an IX stems from the value presented by the IX in keeping Internet traffic local, lowering costs, and saving on International bandwidth for other more important uses.[69]

An integer value of 1 is assigned to this indicator when an IX is present, and 0 when it is not, regardless of the number of IXs per country. In general, there is one IX per country but exceptions exist in which an IX is assigned for a major urban area instead of an entire country. In the United States there are IXs for each state.[70] It is noteworthy that the United Arab Emirates[71] and Egypt[72] are the only ESCWA member countries that posses an IX.

(b) *Competition in local fixed telephony*

The number of main telephone lines is influenced by a country's telecommunication policy. Competition in the fixed telephony sector is an important policy choice that reflects the market structure in a given country.[73] Monopolies are thought to slow down ICT development, lead to higher prices, limited access and limited services. Yet, monopoly in the fixed telephony sector does not necessarily indicate lack of benefits offered by the organization. In fact, there are customer-oriented telecommunications companies that are the sole telephone service providers in their country. UNCTAD labels this indicator as 0 for monopoly, 0.25 for duopoly, 0.5 for partial competition, and 1 for competition in local fixed telephony.

Competition partially exists in the local fixed telephony sector in ESCWA member countries. About half ESCWA member countries have only state-owned fixed telephone lines operators. These countries are Egypt, Iraq, Kuwait, Lebanon, Oman, Syrian Arab Republic and Yemen. Operators in the rest of ESCWA member countries are partially privatized, namely in Bahrain, Jordan, Qatar, Saudi Arabia and United Arab Emirates.[74]

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[67] UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003, p. 14. (UNCTAD/ITE/IPC/2003/1).

[68] Ibid.

[69] Ibid.

[70] UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003. (UNCTAD/ITE/IPC/2003/1).

[71] The Internet Exchange Points Directory: Telegeography. 2003. Available at: http://www.telegeography.com/resources/directories/internet/ix_directory.html.

[72] Flag Telecom. "FLAG Telecom announces launch of CR-IX, the new Internet Exchange in Egypt: collaboration with National Telecom Company establishes new Internet Exchange for the region". Available at: http://www.flagtelecom.com/newsroom/ NewsItem.asp?iNewsID=184.

[73] UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003. (UNCTAD/ITE/IPC/2003/1).

[74] International Telecommunications Union (ITU), "Regional Profile", 2003. Available at: http://www.itu.int/ITU-D/treg/profiles/guide.asp?lang=en.

(c) *Competition in ISPs*

An ISP is a company that provides end-user access to the Internet.[75] Four types of ISPs are identified; backbone, downstream, web-hosting and online service provider. A distinction should be made between licensed and operational ISPs. Competition among ISPs is important for local diffusion of ICTs. When 'policy' allows the establishment of more than one ISP, prices are likely to be affordable and quality of service is likely to improve.[76]

In evaluating the indicator of competition in the ISP market, UNCTAD disregards the different types of ISPs and focuses on competitiveness only. Hence, a value of 1 stands for competitiveness in the market and 0 for monopoly. ISPs in some ESCWA member countries including Egypt, Saudi Arabia and Yemen experience full competition whereas ISPs in Bahrain and Kuwait have only partial competition. Other ESCWA member countries such as Oman, Qatar and the United Arab Emirates each have a single ISP.[77]

6. *Networked Readiness Index*

The Networked Readiness Index (NRI) is a composite indicator defined as "the potential and degree of" preparedness of a given population or community to be part of the "Networked World".[78] The Networked World is defined as a collection of individuals, organizations, firms, governments, educational institutions communicating and interacting with each other through the use of technologies such as PCs and the Internet.[79] The NRI is based on three levels of sub-indices as illustrated in figure 23. Two sub-indices make up the first level, namely, enabling factors and the extent of network use.

Enabling factors indicate the existing conditions and the future potential of a nation's network comprising the following elements:

(a) Network access: composed of network infrastructure and hardware and software support;

(b) Network policy: consisting of existing ICT policy instruments;

(c) Networked society: including the extent of involvement of ICTs in social services, such as education;

(d) Networked economy: comprising e-commerce and certain aspects of e-government.

On the other hand, the extent of network use is made up of the number of Internet users per hundred inhabitants, cellular subscribers per hundred inhabitants, Internet users per host, percentage of computers connected to the Internet, and availability of public access to the Internet.

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[75] M. Minges, "Counting the Net: Internet access indicators." 10th Annual INET Conference-Internet Society, Japan, 18-21 July 2000. Available at: http://www.isoc.org/inet2000/cdproceedings/8e/8e_1.htm.

[76] UNCTAD, *Information and Communication Technology Development Indices*, New York and Geneva, 2003. (UNCTAD/ITE/IPC/2003/1).

[77] International Telecommunications Union (ITU), "Regional Profile", 2003. Available at: http://www.itu.int/ITU-D/treg/profiles/guide.asp?lang=en.

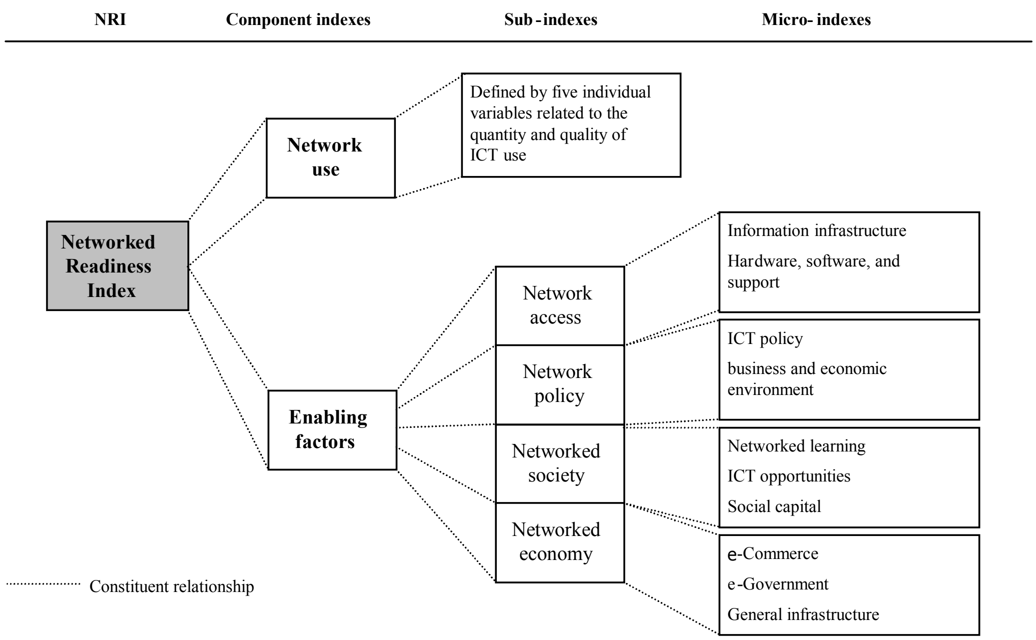
[78] Harvard University. Information Technologies Group, Center for International Development. "The Networked Readiness Index: Measuring the Preparedness of Nations for the Networked World". 2002. Available at: http://www.cid.harvard.edu/cr/pdf/gitrr2002_ch02.pdf.

[79] Harvard University. Information Technologies Group, Center for International Development. "Readiness for the Networked World. What is the Networked World?". 2003. Available at: http://cyber.law.harvard.edu/readinessguide/networkedworld.html.

The NRI of a nation is measured by means of a combination of all the aforementioned sub-indices. Nevertheless, the NRI should not be limited to only quantitative values of the sub-indices; it should also include qualitative measures such as the manner in which ICTs affect the lives of people and the extent to which they benefit from ICTs. Currently, however, the NRI does not extend to qualitative measures.

Only three Arab countries were included in recent studies using the NRI concept, namely, Egypt, Jordan, and Morocco with index values of 3.13, 3.51, and 3.5, respectively (see table 16). These three Arab countries lag far behind developed countries such as the United States, which has an index value of 6.05. Notably, NRI values for these Arab countries also lag behind the NRI value of Israel, estimated at 4.54.

Figure 23. Structure of the Networked Readiness index



Source: Harvard University. Information Technologies Group, Center for International Development. "The Networked Readiness Index: Measuring the Preparedness of Nations for the Networked World". 2002. Available at: http://www.cid.harvard.edu/cr/pdf/gitrr2002_ch02.pdf.

TABLE 16. NETWORKED READINESS INDEX

	Networked readiness	NRI rank
United States	6.05	1
Iceland	6.03	2
Finland	5.91	3
Sweden	5.76	4
Norway	5.68	5
Singapore	5.47	8
United Kingdom	5.31	10
Canada	5.23	12
Taiwan	5.18	15
Germany	5.11	17
Japan	4.86	21
Israel	4.84	22
France	4.71	24
Turkey	3.67	41

TABLE 16 (*continued*)

	Networked readiness	NRI rank
Jordan	3.42	49
India	3.32	54
Philippines	3.27	58
Egypt	3.2	60
Russian Federation	3.17	61
China	3.1	64

Source: Harvard University. Information Technologies Group, Center for International Development. "The Networked Readiness Index: Measuring the Preparedness of Nations for the Networked World". 2002. Available at: http://www.cid.harvard.edu/cr/pdf/gitrr2002_ch02.pdf.

7. *ICTs in education*

The use of ICTs in learning may create a new environment that enhances learning capabilities. Many developed countries are actively seeking to integrate ICTs in primary and secondary education with the aim of rendering students as productive users of technology. Introducing ICTs into educational systems is supported by standards related to technology use targeting both students and teachers. This appears to have been the case in the United States, Europe and many other countries.[80]

Using ICTs in education in the Arab world is still at its early stages with many tasks to be fulfilled including the development of new compatible educational curricula, affecting change in attitudes and disseminating capabilities of teachers and students in technology-related training. Nevertheless, ICTs are making their way into the education systems in countries as Jordan, Lebanon and the United Arab Emirates. The World Bank Institute's ICT for Education programme, which began in 1997 as World Links for Development (WorLD), is an initiative to help developing countries prepare their youth for an age of global information.[81] ICT integration in elementary and secondary levels still needs to take a more pervasive shape in the Arab world.

Table 17 indicates categories of indicators that may be used in assessing ICT applications in education. Clearly, these and other related indicators would need to be considered with more detail in relation to national ICT and educational strategies.

TABLE 17. TYPES OF ICT INDICATORS IN EDUCATION

Indicator area	Description
Infrastructure	Availability of hardware, software and connections Ratio of students to computers Technical support
Teacher preparation	Training in the use of technology for instructional purposes Expertise in applications such as word processing and graphics
Teaching strategies	Integrating applications into the learning activities of students such as locating resources on the Internet The degree to which the teacher is instructive versus constructive
Student use patterns	Technological activities that students take part in Proportion of time in which a student uses the computer Types of connections and software programmes used

Source: Interactive Inc. "Creating Practical Evaluation Templates for Measuring the Impact of Instructional Technology". 2000. Available at: http://www.ed.gov/Technology/techconf/2000/interactive.pdf.

[80] United Nations Educational, Scientific and Cultural Organization (UNESCO), Bangkok, "Developing and Using Indicators of ICT Use in Education", E. Barsaga, 1999. Available at: http://www.unescobkk.org/ips/infoshare/ 4-1-2002/infotech_trends.pdf.

[81] World Bank Group, "World Links for Development", 2003. Available at: http://www.worldbank.org/worldlinks/english/.

C. CONCLUDING REMARKS

ICTs have contributed significantly to the socio-economic conditions in developed countries, and hold several promises for developing countries yet to catch up. This chapter has discussed, in some detail, several widely used ICT indicators, including fixed and mobile telephony, personal computers, and Internet access. Selected data, compiled largely from the ITU, has been provided on these indicators for ESCWA member countries, who lag far behind the world in ICT capacity thereby hindering their transition into the global knowledge-based economy. In many cases, GCC countries that tend to have higher per capita GDP surpassed non-GCC countries in ICT capabilities.

The UNCTAD has defined new indices to measure connectivity, namely, access and policy, which are based on a number of sub-indices, and have been discussed in the chapter. In addition to a good physical ICT infrastructure, there must be an enabling policy and legislative environment. The UNCTAD policy index focuses mostly on competition in local fixed telephony and in the ISP market. Many ESCWA member countries have little competition in any of these two areas because fixed telephone line operators and ISPs are generally state-owned. Relaxing the monopoly on such services could help lower access prices and in turn higher Internet participation.

A composite indicator developed by Harvard University, the NRI is also presented. This indicator measures the preparedness of a given country to enter the networked world. It takes into account both network and policy infrastructure, as well as social and economic factors. The NRI did not appear as relevant to ESCWA member countries as for other more developed countries, since only two countries made it into the NRI ranking, namely, Egypt and Jordan.

The benefits of ICTs have permeated to educational systems around the world, although ESCWA member countries are still at an infancy stage in this respect. The chapter lists indicators particular to ICTs in education, including the availability and type of ICT equipment present in schools, ICT pervasiveness in classes, and the level of expertise in using typical applications, including word processing and graphics.

V. COMPOSITE INDICATOR SYSTEMS

Realization of the role of technological capabilities, coupled with the availability of enabling educational and social conditions, has engendered interest in composite indices. Composite indices are primarily intended to create awareness of opportunities and challenges on a national basis, and to help policy makers in defining directions for strategic action. They have been gaining increased popularity because they provide an overview of performance on a number of factors, especially in the current diverse knowledge-based economy.

A. THE TECHNOLOGY ACHIEVEMENT INDEX

A prime example of composite indicators is TAI, introduced by the UNDP in its 2001 Human Development Report. TAI is a composite indicator that compares the abilities of countries to acquire and implement traditional and new technologies, in addition to their readiness to participate in the global economy.

While the TAI measures technological achievements, it is not a measure of technology development potential or leadership. Rather, it focuses on benchmarking a country based on its participation in creating and using technology. The TAI for 2001 strongly correlated with the UNDP Human Development Index, despite the fact that TAI does not specifically relate technology achievements to human development. Table 18 lists indicators on which the TAI is based.

TABLE 18. DIMENSIONS AND CORRESPONDING INDICATORS OF THE TECHNOLOGY ACHIEVEMENT INDEX

Dimension	Indicator
Creation of technology	Patents granted per capita
	Receipts of royalty and license fees from abroad per capita
Diffusion of recent innovations	Internet hosts per capita
	High and medium technology exports as a share of all exports
Diffusion of old innovations	Logarithm of telephones per capita (mainline and cellular combined)
	Logarithm of electricity consumption per capita
Human skills	Mean years of schooling
	Gross enrolment ratio at tertiary level in science, mathematics and engineering

Source: United Nations Development Programme (UNDP), *Human Development Report 2001*, Making New Technologies Work for Human Development, New York, Oxford University Press, Inc., 2001.

In the 2001 Human Development Report, only 72 countries could be classified in terms of their overall achievement in creating and using technology due to the lack of data for the remaining countries. In fact, the lack of data is also an indicator of little formal innovation taking place in those countries.[82] Finland comes first, with the United States, Sweden and Japan immediately behind. Finland's lead over the United States is largely due to a higher volume of Internet usage and to a greater proportion of citizens with qualifications in advanced science and engineering subjects.

In this same report, the Republic of Korea comes before the United Kingdom, in fifth position, and Singapore is in tenth position, just above Germany. Mexico, in thirty-second, is listed among emerging leaders. India, with its world-class facilities for software engineering in Bangalore, ranks sixty-third, behind the Syrian Arab Republic and Paraguay, countries evidently not in a position to influence high technology in any significant manner. This is likely due to the fact that some of the TAI indicators relate to overall literacy, electricity consumption, telephone density, and so on.

[82] UNDP, *Human Development Report 2001*, Making New Technologies Work for Human Development, New York, Oxford University Press, Inc., 2001.

In general, the situation of the Arab countries with regards to the TAI is not encouraging. To start with, data required for estimating their standing among other nations is largely unavailable. Data of acceptable quality is available only for a handful of countries. Tunisia, at fifty-first position, is the highest-ranking Arab country, while Egypt and the Syrian Arab Republic, occupy positions 56 and 57, respectively.

The TAI is only intended to provide a summary of the achievements of a nation, because of the complexity of measuring and quantifying aspects of technology creation, diffusion and related human skills.[83] The lack of reliable data available further complicates this task. Therefore, TAI may be used as a starting point in a general assessment of national technology capacity.

Two particular issues were targeted in the design of TAI. Firstly, to some extent, the indicator reflects national policy concerns, regardless of technology development. Secondly, the TAI attempts to "discriminate between countries at the lower end of the range" to ensure that the indicator is useful for developing countries as well.[84]

Despite this, TAI remains somewhat selective in its parameters and its ability to represent developing countries whose technological capacity is still at an embryonic stage, as is the case for ESCWA member countries. It may be possible to modify the TAI to include indicators that are more pertinent to the early stages of a country's development in terms of technology and innovation. With this in mind, the following indicators, based on those used in TAI, incorporate suggested modifications. Relevant data on the TAI and these indicators is presented in annex V.

(a) Investment in technology creation: TAI evaluates technology creation based on two sub-indicators, namely, patents and royalty and license fees. Developing countries do not enjoy as much innovative activity as developed countries do, rendering these sub-indicators less relevant. It may be better to incorporate data on R and D expenditure in such cases where allocating funding for R and D can be considered an achievement in itself. Details on R and D efforts in ESCWA member countries were previously discussed in section A of chapter II. Naturally, further aspects of capacity building may also be incorporated.

(b) Diffusion of ICTs: Knowing the positive impacts of ICTs on socio-economic development, it would be beneficial to include other indicators apart from just the number of Internet hosts, which is what TAI incorporates. Technology achievements in ICTs may also be reflected in terms of Internet access, use of personal computers, and the presence of an enabling ICT policy environment, particularly for developing countries where ICT capabilities are only emerging.

(c) Diffusion of technology in agriculture and manufacturing: With specific reference to ESCWA member countries, whose economies are largely agricultural, it is suggested to incorporate data on new and mature technology inputs in agriculture. Data on fertilizer consumption and tractor usage is provided in the 2001 UNDP Human Development Report, but are not incorporated in the calculations of the TAI (see box 21 for brief notes on technology in agriculture in the region). It is also suggested not to exclude low technology exports for countries that export little or no high or medium technology.

Box 21. Diffusion of technology in agriculture in selected Arab countries

The use of technology in agricultural activities in the region shows that there has been a general increase in both the number of kilograms of fertilizer used and in the number of tractors used per hectare. Egypt, Kuwait and the United Arab Emirates have a rate of fertilizer consumption of over 300 kilograms per hectare (kg/h), which at 114.6 kg/h is even higher than the average in high human development countries. Egypt has the highest rate in the region with 27.3 tractors per hectare, compared with the average of 40.2 tractors per hectare in countries that have achieved high human development according to the 2001 UNDP Human Development Report. Other Arab countries have relatively low fertilizer consumption, well below the world average. Mauritania and the Sudan show the lowest fertilizer consumption with a mere 4.2 and 2.2 kg/h, respectively.

[83] UNDP, *Human Development Report 2001*, New York: Oxford University Press, Inc., 2001.

[84] Ibid.

B. Measuring the Knowledge-Based Economy[85]

The European Commission has devised two composite indicators to measure the complex and multidimensional aspect of the knowledge-based economy. The use of such indicators, which has become an emerging field, provides a view of the "big picture" by aggregating a number of different variables related to the economy.

The first indicator measures the level and growth of investment that countries have made in knowledge, while the second revolves around the level and growth of performance as a result of these investments.

1. *Investment in the knowledge-based economy*

The composite indicator for investment in the knowledge-based economy addresses the creation and diffusion of new knowledge, two crucial dimensions of investment. The indicator is calculated based upon a set of sub-indicators related to R and D effort, such as investment in human capital, quality of education, purchase of new technology, and modernization of public services.[86]

These sub-indicators have been identified into two conceptual groups, namely, knowledge creation and knowledge diffusion, and have also been assigned weighting factors (see table 19). Evidently, the sub-indicator of total education spending per capita has been awarded the highest weight factor, 7/24, particularly because it incorporates both knowledge creation and diffusion. Accounting for these two conceptual groups allows for comparability as to which countries emphasize more on the creation of knowledge and which focus more on the acquisition and diffusion of new knowledge from abroad.

TABLE 19. COMPONENT INDICATORS AND WEIGHTINGS FOR THE COMPOSITE INDICATOR ON INVESTMENT IN THE KNOWLEDGE-BASED ECONOMY

Component indicators	Conceptual group	Weight
Total R and D (GERD) per capita	Knowledge *creation*	2/24
Number of researchers per capita	Knowledge *creation*	2/24
New S and T PhDs per capita	Knowledge *creation*	4/24
Total education spending per capita	Knowledge *creation* and Knowledge *diffusion*	4/24 + 3/24
Life-long learning	Knowledge *creation*: human capital	3/24
E-government	Knowledge *diffusion*: information infrastructure	3/24
Gross fixed capital formation (excluding construction)	Knowledge *diffusion*: new embedded technology	3/24

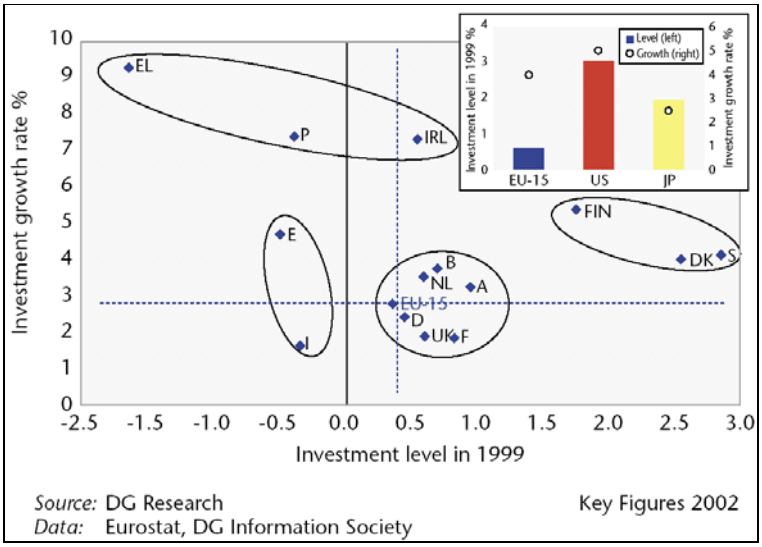
Source: European Commission, Research, "Towards a European Research Area: Science, Technology and Innovation - Key Figures 2002". Luxembourg: Office for Official Publications for the European Communities. Research Directorate General, 2002.

Data availability is an important factor in the development and computation of a composite indicator. The sub-indicators chosen were, as much as possible, ones with adequate data coverage and availability, along with reasonable quality and comparability.

[85] This section is based on information from the European Union. European Commission, Research, "Towards a European Research Area: Science, Technology and Innovation - Key Figures 2002". Luxembourg: Office for Official Publications for the European Communities. Research Directorate General, 2002.

[86] For example, e-government.

Figure 24. Composite indicator of investment in the knowledge-based economy. Relative country positions in 1999 and annual growth rate (1995-1999)



Source: European Commission, Research, "Towards a European Research Area: Science, Technology and Innovation - Key Figures 2002". Luxembourg: Office for Official Publications for the European Communities. Research Directorate General, 2002.

Note: Due to non availability of data for United States and Japan, three sub-indicators (education spending, e-government and life-long learning) were not included in the comparison between EU, United States and Japan. This explains why the two values for EU-15 are slightly different in figure 24.

Referring to figure 24, the horizontal axis shows the investment level of each country compared to other EU member states. The investment growth rate of each country is represented on the vertical axis. In terms of both investment level and growth, figure 24 illustrates that the EU was lagging behind the United States in 1999.

2. *Performance in the knowledge-based economy*

While the composite indicator on investment groups its sub-indicators under knowledge creation and knowledge diffusion, this second indicator identifies four most important elements of performance in the transition to the knowledge-based economy.[87] They are as follows:

(a) Productivity;
(b) S and T performance;
(c) Usage of information infrastructure;
(d) Effectiveness of the education system.

The sub-indicators and their respective weights for the indicator on performance are shown in table 20. Meanwhile, figure 25 shows the performance level of each country in 1999 on the horizontal axis, and the performance growth over the period 1995-1999 on the vertical axis.

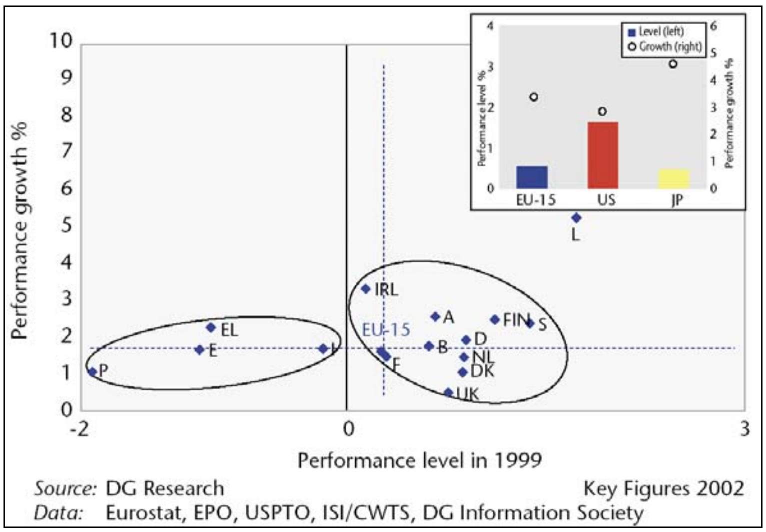
[87] European Commission, Research, "Towards a European Research Area: Science, Technology and Innovation - Key Figures 2002". Luxembourg: Office for Official Publications for the European Communities. Research Directorate General, 2002.

TABLE 20. COMPONENT INDICATORS AND WEIGHTINGS FOR A COMPOSITE INDICATOR ON PERFORMANCE IN THE KNOWLEDGE-BASED ECONOMY

Component indicators	Conceptual group	Weight
GDP per hours worked	Productivity	4/16
European and US patents per capita	S and T performance	2/16
Scientific publications per capita	S and T performance	2/16
E-commerce	Output of the information infrastructure	4/16
Schooling success rate	Effectiveness of the education system	4/16

Source: European Commission, Research, “Towards a European Research Area: Science, Technology and Innovation - Key Figures 2002”. Luxembourg: Office for Official Publications for the European Communities. Research Directorate General, 2002.

Figure 25. Composite indicator of performance in the knowledge-based economy. Relative country positions in 1999 and annual growth rate (1995-1999)



Source: European Commission. “Towards a European Research Area. Science, Technology and Innovation. Key Figures 2002”. Luxembourg: Office for Official Publications for the European Communities. Research Directorate General, 2002.

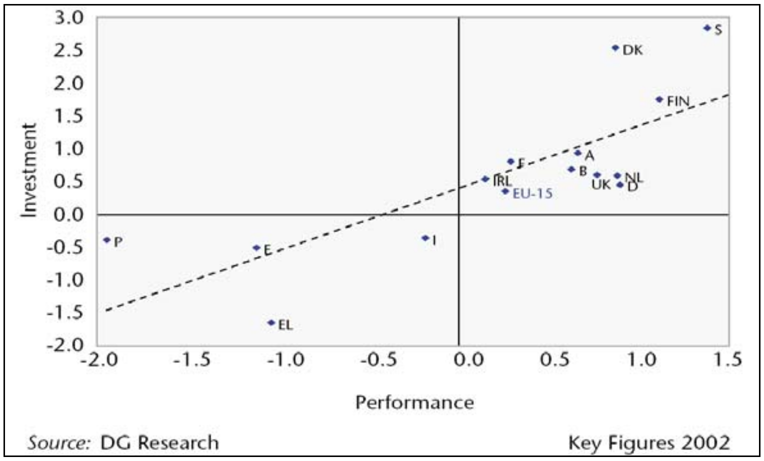
Note: Due to non-availability of data for United States and Japan, two sub-indicators (e-commerce and schooling success rate) were not included in the comparison between EU, United States and Japan. This explains why the two values for EU-15 are slightly different in figure 25.

In terms of performance level, the EU was also lagging behind the United States in 1999, but its higher performance growth rate shows increased efforts in the transition to the knowledge-based economy. In order to diminish the existing gap, despite the higher growth rate in the EU, it is necessary not only to increase the amount of investment, but also to improve its allocation and implementation.

3. *The relation between investment and performance*

Countries must carefully judge the needs of the different areas in their economies, and distribute investment resources accordingly. They may find that, rather than allocating investment to knowledge on a wide scale, focusing on enhancing the performance of a particular field will attract foreign capital, and enhance the overall performance and competitiveness of their economies on the long run.

Figure 26. Performance versus investment of the EU member States in 1999



Source: European Commission. "Towards a European Research Area. Science, Technology and Innovation. Key Figures 2002". Luxembourg: Office for Official Publications for the European Communities. Research Directorate General, 2002.

According to figure 26, there is a visible relationship between investment and performance in the knowledge-based economy, despite a time lag between investment and effective results. The best performers are those who have invested more in research, education and innovation.

A reinforced knowledge infrastructure and an encouraging environment for innovation are key for strengthening the position of a country in the knowledge-based economy. This would require countries to pursue structural changes in relevant policies to highlight the importance of research, education, innovation and the information society.[88]

C. CONCLUDING REMARKS

Composite indicators have been developed in order to capture several dimensions at once. They are particularly useful when analysing national STI capacity because they can take into consideration technology factors as well as social and economic conditions.

The TAI developed by UNDP, measures national technological achievements, and benchmarks countries based on their ability to create and use technology. Scarcity and unreliability of data did not allow for all countries to be ranked according to their overall technology achievement. This was mainly the case for ESCWA member countries. Modifications for the TAI have been suggested keeping in mind the need to better represent developing countries, where technology and innovation are still at very early stages.

With specific reference to the knowledge-based economy, the EU has developed two composite indicators to measure investment and performance. Components of the composite indicator for investment in the knowledge-based economy include the number of researchers, the availability of e-government, research expenditure, and education spending, which possesses the most weight. The composite indicator for performance in the knowledge-based economy focuses on productivity, S and T performance, and the usage and effectiveness of both the information infrastructure and the education system.

Provided that reliable data is available, these composite indicators may be adopted in ESCWA member countries. It may also be possible to customize certain indicators to adapt to developing stages of STI capacity in the region.

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[88] European Commission, Research, "Towards a European Research Area: Science, Technology and Innovation - Key Figures 2002". Luxembourg: Office for Official Publications for the European Communities. Research Directorate General, 2002.

VI. CONCLUSION

Over the past few decades, significant progress has been made in monitoring national STI capabilities. Improved understanding of the paths taken by scientific and technological development, their impact on innovation, and through it, on national competitiveness and productivity, has given rise to new and more complex indicator systems, which are now in use in all developed and most industrializing countries around the world.

Mastering the ability to use such indicators will be crucial for national socio-economic policy and decision-making. National development strategies will be in greater need than ever before for these improved tools in order to evaluate the status of national STI capabilities, forecast future prospects and institute appropriate measures for the achievement of desired changes.

Attempts are being made in almost all ESCWA member countries to devise strategies aimed at enhancing national STI capabilities. These strategies should allocate top priority to overcoming obstacles to effective STI monitoring and evaluation. Two of the main difficulties often encountered in ESCWA member countries in this regard are:

(a) Lack of institutional arrangements dedicated to STI monitoring and evaluation;

(b) The limited degree of agreement, among concerned institutions, on common definitions for even some of the main entities addressed in STI performance evaluation exercises.

The need for setting up national "observatories" dedicated to monitoring STI capabilities should, therefore, be an integral part of national STI policy design and implementation strategies. Additionally, it would be essential to create modalities that promote demand for information produced by these observatories, such as a national STI policy research units capable of analysing national observatory outputs for the benefit of policy and decision-making. Designs aimed at implementing national STI strategies should include pilot activities aimed towards these ends and should be initiated as early as possible in the process of STI strategy implementation.

It will be essential for national STI observatories and policy research units to reflect the multifaceted character of national STI capabilities and the large range of issues linked to their evolution. A considerable degree of specialization must be reflected in the internal structure and manpower needs of those observatories and policy research arrangements.

Monitoring the evolution of STI capabilities may certainly be facilitated by developments in ICTs. It should thus be possible to set up specialist statistical units within universities and departments of education at the national and district levels, to carry out collection and initial analysis of information relevant to their scope of activities. Such endeavours would ensure constant up-to-date contributions to STI performance evaluation with reference to STI dissemination activities, more specifically the quality and extent of STI human resource development. Similar units can be set up at the level of industrial enterprises. They would be concerned with data on technology transfer and utilization activities, and product and process innovations, among other issues, with minimal expenditure of costs and manpower efforts. Similar activities may be undertaken by agricultural extension services in monitoring STI related activities. Information from all such units could be collected and analysed centrally, and results could be used in implementing policy and institutional change.

While distributed observatories and policy research units may be made to act as a virtual national STI observation and policy design body, facilitated by ICTs, there would still be need for establishing a central institutional entity to coordinate activities, oversee networking arrangements and institute essential continuous training.

Whatever strategy is developed for enhancing national STI capabilities, any viable performance assessment must be established on the basis of clear concepts shared by all parties involved in the creation, dissemination, transfer and utilization of STI knowledge within the institution or sector under consideration.

This will almost always require thorough surveys of STI status and related policies, tasks that may only be effectively undertaken and integrated nationally rather than at the sectoral and institutional levels.

The fact that almost all ESCWA member countries are in the process of formulating or updating national STI policies, with only limited monitoring and evaluation capabilities in place, may call for gradual approaches to the implementation of STI indicators. Primary attention must be allocated to mastering S and T related indicators, a relatively simple task in comparison to other more complex areas, particularly innovation and STI knowledge utilization measurement. However, simultaneous attempts will need to be made for branching more complex, and more rewarding areas of national STI monitoring and evaluation into these areas.

It is necessary for member countries to exert effort into moving towards internationally adopted systems of indicators and analysis methodologies. Annexes I and II list indicators categorized according to their specific function in national STI systems. Implementing several of the indicator systems listed in these annex tables, especially those relating to innovation and utilization of STI knowledge, will not be a straightforward affair in all member countries. It will require substantial research activity, thus indicating the necessity for linking national STI observatories to policy research facilities.

In most member countries, implementation of some of the indicator systems listed in the above tables, especially those relating to innovation and the utilization of STI knowledge, will not be straightforward. Many aspects of implementation will require a great deal of research activity, reinforcing the need to link national STI observatories with policy research facilities.

In summary, greater efforts need to be expended in all ESCWA member countries in the collection and analysis of statistics and other information on the evolution of their STI capabilities. Additional manpower, financial and institutional resources will be required:

(a) To develop national systems of indicators that reflect national aspirations and particularities, while maintaining emphasis on compatibility with regional and international metrics;

(b) To establish units dedicated to the development and implementation of STI indicators as part of efforts to review and update national STI policies;

(c) To allocate resources for training activities, capacity building, development of software packages, and so on, thereby standardizing the use of STI indicators.

These constitute basic requirements for conducting STI audits, which in turn make up an essential policy tool for joining the global economy of the information age. It is imperative for the planning process to possess capabilities for analysing STI at different levels including: the firm, industry, country, and region. Neglecting this need can cause developing countries to lose their ability to benchmark themselves against others, efficiently plan ahead, and improve their innovation systems.

ANNEXES

Annex I

SELECTED SCIENCE, TECHNOLOGY AND INNOVATION INDICATORS

ANNEX TABLE 1. INDICATORS RELATED TO STI CREATION

RESEARCH AND DEVELOPMENT	
Indicator	Definition
Gross Domestic Expenditure on R and D (GERD)	Gross Domestic Expenditure on Research and Development (GERD) is total intramural expenditure on R and D performed on the national territory during a given period.
GERD as a percentage of GDP	The Gross Domestic Expenditure on R and D expressed as a percentage of the Gross Domestic Product.
GERD per capita	The Gross Domestic Expenditure on R and D divided by the total population.
Percentage of GERD allocated to different sectors	The percentage of Gross Domestic Expenditure on R and D in the following different sectors: business enterprise, government, private non-profit, higher education, abroad.
Percentage of GERD financed by organizations abroad	The percentage of Gross Domestic Expenditure on R and D financed by organizations abroad out of the total GERD. The sections abroad include: - All institutions and individuals located outside the political borders of a country, except vehicles, ships, aircraft and space satellites operated by domestic entities and testing grounds acquired by such entities; - All international organizations (except business enterprises), including facilities and operations within the country's borders.
Full-time equivalent (FTE) researchers per capita	Full-time equivalent staff is a true measure of the volume of R and D. One FTE may be thought of as one person-year. Personnel should be measured as the number of person-years on R and D over the same period as the expenditure series.
Number of R and D support personnel	Other R and D supporting staff include skilled and unskilled craftsmen, secretarial and clerical staff participating in R and D projects or directly associated with such projects.
Number of national institutions involved in R and D	All National institutions including Universities and other organizations involved in R and D. According to the Frascati Manual, research and experimental development comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R and D must be distinguished from a wide range of related activities with a scientific and technological basis which should be excluded when measuring R and D, including education and training, other related scientific and technological activities, other industrial activities, administration and other supporting activities.
National/regional prizes dedicated as incentives to researchers and inventors	The number of all national and regional prizes dedicated as incentives to researchers and inventors.
Number of registered patents	A patent is defined by the Oslo Manual as a legal property right over an invention, which is granted by national patent offices. Patent statistics are increasingly used in various ways by technology students as indicators of the output of invention activities.
Publications in refereed journals	A refereed journal has a structured reviewing system in which at least two reviewers, excluding in-house editors, evaluate each unsolicited manuscript and advise the editor as to acceptance or rejection.
Co-authorship and other forms of STI cooperation with developed countries	Co-authored publications involve authors from at least two different countries and are defined by research papers in which there are addresses of at least two authors in different countries. Note that the method of counting co-authored publications involves including all countries participating in the publication.

Sources: Adapted from European Commission, Community Research, "Third European Report on Science and Technology Indicators", Brussels, 2003. I. Nonaka, and H. Takeuchi, *The Knowledge-Creating Company*, Oxford University Press, New York, 1995. University of North Florida, "What is a Refereed Article", 2003. Available at: http://www.unf.edu/library/guides/refereedarticle.html.

ANNEX TABLE 2. INDICATORS RELATED TO STI DISSEMINATION

Indicator	Definition
EDUCATION AND LITERACY	
Indicator	Definition
Literacy rate (percentage)	Percentage of persons aged 15 and over who can read and write a short, simple statement on their everyday life.
Growth in literacy rate	Percentage of increase of literacy rate over several years.
Primary school enrolment	Ratio of children of all ages enrolled in primary school to the country's population of school-age children (ages 6-11).
Secondary school enrolment	Ratio of children of all ages enrolled in secondary school to the country's population of school-age children (12-17).
Secondary technical enrolment average	Average over several years of the ratio of pupils preparing directly for a trade or occupation other than teaching, to total secondary school enrolment.
HIGHER EDUCATION	
Indicator	Definition
Number of universities and other institutions of higher education	The total number of national universities and institutions of higher education.
Tertiary school enrolment	Ratio of the number of pupils enrolled in all post-secondary schools and institutions by the population in the 18-24 age group.
Number of students enrolled in STI fields (Bachelors, Masters, PhD)	Students currently enrolled in the natural and applied sciences, including medicine, as a percentage of total enrolled students.
Number of graduates in STI fields (Bachelors, Masters, PhD)	Tertiary graduates in the natural and applied sciences, including medicine, as a per cent of total graduates.
Higher education expenditure	Capital expenditure on education is expenditure for assets that last longer than one year. It includes expenditure for construction, renovation and major repairs of buildings and the purchase of heavy equipment or vehicles. The current expenditure on education is the expenditure for goods and services consumed within the current year and which would need to be renewed if there were a need for prolongation the following year. It includes expenditure on: staff salaries and benefits; contracted or purchased services; other resources including books and teaching materials; and other current expenditure such as furniture and equipment.
Higher education expenditure as a percentage of GDP	Total expenditure on higher education expressed as a percentage of the GDP.
Higher education expenditure per capita	The higher education expenditure divided by the total population.
Number of S and T colleges in universities	The number of Science and Technology colleges that provide studies in the following fields: engineering, natural sciences, mathematics and computers.
Number of H and SS colleges in universities	The number of Humanities and Social Sciences colleges that offer studies in the following fields: social and behavioural sciences, journalism and information, business and administration, and law.
Distribution of S and T colleges in universities by area	The ratio of the different areas of Science and Technology colleges (Basic Sciences, Computer, Engineering, Medicine, Pharmacy, Dentistry, Nursing, Para Medicine, Agriculture, Veterinary Science, Others) in universities to the total number of Science and Technology colleges.

Sources: Adapted from European Commission, Community Research, "Third European Report on Science and Technology Indicators", Brussels, 2003. United Nations Educational, Scientific and Cultural Organization (UNESCO), "Technical Guidelines for Education Statistics", 2003. Available at: http://portal.unesco.org/uis/ev.php?URL_ID=5189&URL_DO=DO_TOPIC&URL_SECTION=201. World Bank Group. "Competitiveness Indicators", 2003. Available at: http://wbln0018.worldbank.org/psd/compete.nsf/e24271d1df909fb38525650c005d9097/ab417cfa708544f58525650c005d9367?OpenDocument.

ANNEX TABLE 3. INDICATORS RELATED TO STI TRANSFER

Contracts	
Indicator	Definition
Number of contracts dedicated to consultancies and acquisition to know-how across sectors and countries	The number of consultancy contracts concluded in the following sectors: agriculture and fishing, defence, industry, infrastructure, services, tourism and transport.
Value of contracts dedicated to consultancies and acquisition to know-how across sectors and countries	The value of consultancy contracts concluded in the following sectors: agriculture and fishing, defence, industry, infrastructure, services, tourism and transport.
Number of industrial contracts concluded by sector	The number of industrial contracts concluded in the following fields: cement and glass, metallurgical, oil and gas, petrochemicals, pharmaceutical, power, waste management, water and others.
Number of infrastructure contracts concluded by sector	The number of infrastructure contracts concluded in the following fields: electrical, housing and offices, port, power, telecommunications and water.
Value of industrial contracts concluded by sector	The value of industrial contracts concluded in the following fields: cement and glass, metallurgical, oil and gas, petrochemicals, pharmaceutical, power, waste management, water and others.
Value of infrastructure contracts concluded by sector	The value of infrastructure contracts concluded in the following fields: electrical, housing and offices, port, power, telecommunications and water.

ANNEX TABLE 4. INDICATORS RELATED TO STI UTILIZATION

Employment[a/]	
Indicator	Definition
Employment in industry (percentage of total employment)	The industry sector includes mining and quarrying (including oil production), manufacturing, construction, electricity, gas and water.
Employment in services	Services include wholesale and retail trade, restaurants and hotels; transport, storage, communications; financing, insurance, real estate and business services; community, social and personal services.
Employment in industry, female	The number of females employed in industry expressed as a percentage of the total number of people employed in industry.
Employment in services, male	The number of males employed in services expressed as a percentage of the total number of people employed in industry.
Technology transfer	
Indicator	Definition
Exports of high technology	High technology exports are products with high R and D intensity. They include high technology products such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.
Exports of medium technology	Automotive products, manufacturing equipment (such as agricultural, textile and food processing machinery), some forms of steel (tubes and primary forms) and chemical products such as polymers, fertilizers and explosives.
Exports of low technology	Low technology exports include textiles, paper, glassware, and basic steel and iron products (such as sheets, wires and un-worked casting).

Source: United Nations Development Programme (UNDP), *Human Development Report 2002*, Deepening Democracy in a Fragmental World, New York: Oxford University Press, Inc., 2002. World Bank Group, *World Development Indicators 2003*, Washington D.C., USA, 2003.

a/ The concept of employment generally refers to people above a certain age who worked, or who held a job, during a reference period. Employment data include both full-time and part-time workers. World Bank Group, *World Development Indicators 2003*, Washington D.C., USA, 2003.

ANNEX TABLE 5. GDP PRODUCTIVITY INDICATORS

Indicator	Definition
Gross Domestic Investment as a percentage of GDP	Gross Domestic Investment (GDI) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets cover land improvements (fences, ditches, drains and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like including commercial and industrial buildings, offices, schools, hospitals, and private residential dwellings.
Private Investment as a percentage of Gross Domestic Fixed Investment	Private investment covers outlays by the private sector (including private non-profit agencies) on additions to its fixed domestic assets. Gross domestic fixed investment includes similar outlays by the public sector.
Net Foreign Direct Investment (FDI) as a percentage of GDP	Net change in foreign investment between the reporting country and the rest of the world. Foreign direct investments include all capital transactions that are made to acquire a lasting interest (usually 10 per cent or more of the voting stock) in an enterprise operating in a country other than that of the investor. FDI is the sum of equity capital, reinvestment of earnings, other long-term capital and short-term capital as shown in the balance of payment.
Growth of GDP	Average annual growth of real Gross Domestic Production per worker.

Source: World Bank Group. “Competitiveness Indicators”, 2003. Available at: http://wbln0018.worldbank.org/psd/compete.nsf/e24271d1df909fb38525650c005d9097/ab417cfa708544f58525650c005d9367?OpenDocument.

ANNEX TABLE 6. INDICATORS RELATED TO PRODUCT AND PROCESS INNOVATION

Indicator	Definition
PRODUCT INNOVATION	
New technology products introduced	A quantitative indicator supported by qualitative information on the number of new products introduced by a given sector or segment embodying new technology inputs.
Expenditure on new technology products	Presents information on expenditure allocated to the acquisition or development of new products embodying new technology inputs by sector or segment.
Export of technologically new products (as percentage of total exports)	Indicates the percentage of technologically new products exported in relation to total exports.
Market penetration of products incorporating new technology inputs	Presents information on the extent of dissemination of products incorporating new technology inputs. This indicator may have to target specific segments and sectors at the outset.
PROCESS INNOVATION	
Indicator	Definition
Process improvements introduced	Presents information on the number of processes introduced that are based on new technology inputs or that utilize new technology in production or service activities in a segment or sector under consideration.
Investment in new process equipment	Provides numerical information on expenditure dedicated to the purchase, maintenance and servicing of processes incorporating new technology inputs in any given segment or sector.
Extent of process automation in the segment/sector/industry	This indicator is directly related to the one listed above, but with reference to technology inputs targeting automation in particular.

<u>Annex II</u>

SELECTED INFORMATION AND COMMUNICATION TECHNOLOGY INDICATORS*

ANNEX TABLE 7. ICT INFRASTRUCTURE AND ACCESS INDICATORS

Indicator	Definition
Telephone main lines in operation (per 100 inhabitants)	Refers to a telephone line connecting the subscriber's terminal equipment to the public switched network and which has a dedicated port in the telephone exchange equipment. Note that one main line could serve several subscribers.
Main lines for residential use	The number of main lines serving households (namely, lines which are not used for business government or other professional purposes or as public telephone stations).
Main lines in urban areas	The number of main lines in urban areas by the total number of main lines in the country.
Waiting list	Shows the number of applications for a connection to a mainline that have been held up by a lack of technical capacity.
Waiting time	Shows the approximate number of years applicants must wait for a telephone line.
Revenue per line ($)	Refers to the revenue received by firms per mainline for providing telecommunications services.
Cost of local call ($ per three minutes)	The cost of a three-minute peak rate fixed-line call within the same exchange area using the subscriber's equipment (that is, not from a public phone).
Cost of call within region ($ per three minutes)	The cost of a three-minute peak rate fixed-line call within the region
Cost of call to US ($ per three minutes)	The cost of a three-minute peak rate call from the country to the United States.
Number of fixed lines operators	A telephone operator or a switchboard operator is a person who helps callers reach the person they are calling.
ISDN subscribers	The number of subscribers to the Integrated Services Digital Network. This can be separated by basic rate interface service and primary rate.
Leased lines subscribers	Leased circuits refer to a two-way link for the exclusive use of a subscriber regardless of the way it is used by the subscriber (such as, switched subscriber or non-switched, or voice or data). Leased lines can be either national or international in scope. In reporting this indicator, only the number of lines should be included, not the number of network termination points.
Initial cost ($)	The cost in dollar of the initial installation charge.
Monthly charge ($)	The monthly rental charge of a telecommunication subscription.
Outgoing traffic (minutes per subscriber)	Refers to the total telephone traffic measured in minutes and that originated in the specified country with a destination outside the country.
Mobile phones subscribers (per 100 inhabitants)	Cellular telephone subscribers refers to users of portable telephones subscribing to an automatic public mobile telephone service which provides access to the Public Switched Telephone Network (PSTN) using analogue or digital cellular technology.
TV receivers	The total number of television sets in use. Some countries have a licensing scheme where television sets must be registered. Since households may have more than one television receiver or may not register, the number of licensed receivers may understate the true number.
Cable subscribers	Refers to the number of cable television subscribers.
Newspaper circulation	Average circulation of a "daily, general interest newspaper" (defined as a news periodical published at least four times a week) per 1,000 people.

Sources: AnsMe.com Dictionary, 2003. Available at: http://define.ansme.com/. International Telecommunication Union (ITU), "Telecommunication Indicators Handbook", 2003. Available at: http://www.itu.int/ITU-D/ict/publications/world/material/handbook.pdf. World Bank Group. "Competitiveness Indicators", 2003. Available at: http://wbln0018.worldbank.org/psd/compete.nsf/e24271d1df909fb38525650c005d9097/ab417cfa708544f58525650c005d9367?OpenDocument. World Bank Group, "ICTs at a Glance tables – Definitions and Sources", 2002. Available at: http://www.worldbank.org/data/countrydata/ictnotes.htm.

* This draft collection of indicators has been compiled by the ICT division of ESCWA.

ANNEX TABLE 8. COMPUTERS AND INTERNET INDICATORS

Indicator	Definition
PCs	Number of computers designed for single person use (though they may be used by many users and/or run unattended).
PCs in education	The number of PCs installed in educational establishments, whether primary or secondary schools or universities.
Networked PCs	Refers to the proportion of the total installed base of personal computers that are connected to a LAN.
Internet subscribers	The number of persons and organizations paying for access to the Internet.
Internet users	The total number of persons with access to the worldwide network.
Dial-Up Internet tariff	Consists of two components: telephone usage charges (monthly subscription, line rental and call charge paid to the telephone company), and Internet access charges (paid to the ISP).
Dial-Up Internet traffic	The volume of Internet Dial-Up traffic in minutes.
Access to Internet	Number of inhabitants that have access to the Internet (at home, work or school) but who may not necessarily use it.
Awareness of Internet	Number of inhabitants that are aware of the Internet.
Internet hosts	A host is a domain name that has an IP address record associated with it. This would be any computer system connected to the Internet (via full- or part-time, direct or Dial-Up connections).
ISPs	Number of companies that provide end-user access to the Internet. When necessary, a distinction should be made between "licensed" and "operational" ISPs.
Internet monthly access charges, ISP monthly charges ($)	The monthly Dial-Up access charge for 20 hours of use. It excludes the initial ISP connection charge. Peak and off-peak prices are averaged.
Available National Bandwidth	Bandwidth has a general meaning of how much information can be carried in a given time period (usually a second) over a wired or wireless communications link. For example, a link with a broad bandwidth - that is, a broadband link - is one that may be able to carry enough information to sustain the succession of images in a video presentation.
Secure Servers availability	Secure servers are servers using encryption technology in Internet transactions.
Local online content	The local online content includes web pages related to the following fields: news, enterprises, education, entertainment, portals, discussion groups and general information.
Top-Level Domain Names (TLDNs per 10,000 inhabitants)	A top-level domain (TLD) identifies the most general part of the domain name in an Internet address. A TLD is either a generic top-level domain (gTLD), such as "com" for "commercial," "edu" for "educational," and so forth, or a country code top-level domain (ccTLD), such as "fr" for France or "is" for Iceland.
Academic Domain Names (percentage)	The .edu academic domain is one of the seven original top-level subdivisions of the Internet Domain Name System (DNS). The .edu domain is intended for regionally accredited degree-granting institutions of higher education. The percentage of academic domain names is the number of universities owning a website to total number of universities.
NRI	Readiness is the degree to which a community is prepared to participate in the Networked World. It is gauged by assessing a community's relative advancement in the areas that are most critical for ICT adoption and the most important applications of ICTs. When considered together in the context of a strategic planning dialogue, an assessment based on these elements provides a robust portrayal of a community's readiness.
e-government Index	An index that tends to reflect a country's economic, social and democratic level of development.

Source: International Telecommunication Union (ITU), "Arab States Telecommunication Indicators", 2000. http://www.itu.int/ITU-D/ict/statistics/at_glance/ARTI00_E.pdf. World Bank Group, "ICTs at a Glance tables – Definitions and Sources", 2002. http://www.worldbank.org/data/countrydata/ictnotes.htm. United Nations Online Network in Public Administration and Finance (UNPAN). "Global Survey of E-Government", 2003. http://www.unpan.org/egovernment2.asp. Minges, M. "Counting the Net: Internet access indicators." 10th Annual INET Conference-Internet Society, Japan, July 18-21, 2000. http://www.isoc.org/inet2000/cdproceedings/8e/8e_1.htm. EDUCAUSE, 'What is the .edu domain?". http://www.educause.edu/asp/faq/faq.asp?code=EDUGENERAL. SearchNetworking.com, glossary, 2003. http://searchnetworking.techtarget.com/glossaryPage/0,294242,sid7,00.html. SearchWebservices.com, glossary, 2003. http://searchwebservices.techtarget.com/glossary/0,294242,sid26,00.html. Harvard University. Information Technologies Group, Center for International Development. "Readiness for the Networked World. What is Readiness?". 2003. http://cyber.law.harvard.edu/readinessguide/ readiness.html.

ANNEX TABLE 9. ICT EXPENDITURE INDICATORS

Indicator	Definition
Telecom expenditures	Current expenditure means expenditure other than investments; it consequently refers to the running of telecommunication services on an annual basis.
ICT expenditures	Include external spending on information technology (spending on products purchased by businesses, households, governments, and education institutions from vendors or organizations outside the purchasing entity), internal spending on information technology (spending on internally customized software, capital depreciation, and so on).
ICT expenditures as percentage of GDP	The percentage of ICT expenditures out of the GDP.
ICT expenditures per capita	The value of ICT expenditure divided by the number of the population.

Source: International Telecommunication Union (ITU), "Telecommunication Indicators Handbook", 2003. Available at: http://www.itu.int/ITU-D/ict/publications/world/material/handbook.pdf. World Bank Group, "ICTs at a Glance tables – Definitions and Sources", 2002. Available at: http://www.worldbank.org/data/countrydata/ictnotes.htm.

ANNEX TABLE 10. ICT CAPACITY BUILDING INDICATORS

Indicator	Definition
Scientists and engineers in R and D in ICTs	Scientists and Engineers engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the planning and management of R and D projects.
R and D expenditures in ICTs	R and D expenditures are current and capital expenditures on creative, systematic activity that increases the stock of knowledge. Included are fundamental and applied research and experimental development work leading to new devices, products, or processes.
R and D expenditures in ICTs as percentage of Gross National Income	The value of R and D expenditure in ICTs expressed as a percentage of the Gross National Income.

Source: United Nations Educational, Scientific and Cultural Organization (UNESCO), "How to understand the statistics presented in the 1999 UNESCO Statistical Yearbook on Culture and Communication", 2002. Available at: http://portal.unesco.org/uis/ev.php?URL_ID=5065&URL_DO=DO_TOPIC&URL_SECTION=201&reload=1049192458. World Bank Group, "ICTs at a Glance tables – Definitions and Sources", 2002. Available at: http://www.worldbank.org/data/countrydata/ictnotes.htm.

ANNEX TABLE 11. ICT LAWS AND REGULATIONS INDICATORS

Indicator	Definition
Laws relating to ICT use	Measures the efficacy of laws relating to electronic commerce, digital signatures, and consumer protection. Ratings range from 1 to 7; the higher the rating the better.
Patent law	A patent is defined by the Oslo Manual as an exclusive right granted for an invention, which is a product or a process that provides a new way of doing something, or offers a new technical solution to a problem. A patent provides a monopoly to its owner (with limited duration) for exploiting the patented invention, as a counterpart for disclosure (which is intended to allow a broader social use of the discovery).
Trademark law	A trademark is defined as a distinctive sign which identifies certain goods or services as those produced or provided by a specific person or enterprise. Its origin dates back to ancient times, when craftsmen reproduced their signatures, or "marks" on their artistic or utilitarian products. Over the years, these marks evolved into today's system of trademark registration and protection. The system helps consumers identify and purchase a product or service because its nature and quality, indicated by its unique trademark, meets their needs.
e-commerce law	e-commerce or electronic commerce is the buying and selling of goods and services on the Internet, especially the World Wide Web. In practice, this term and a newer term, e-business, are often used interchangeably.
e-signature	e-signature is an electronic signature that can be used to authenticate the identity of the sender of a message or the signer of a document, and possibly to ensure that the original content of the message or document that has been sent is unchanged. Digital signatures are easily transportable, cannot be imitated by someone else, and can be automatically time-stamped. The ability to ensure that the original signed message arrived means that the sender cannot easily repudiate it later.

ANNEX TABLE 11 (*continued*)

Indicator	Definition
Piracy rate (percentage)	Software piracy is defined as the illegal copying, distribution, or use of software. Software piracy causes significant lost revenue for publishers, which in turn results in higher prices for the consumer. Some software publishers go out of business because of software piracy. Others are discouraged from entering markets where software piracy rates are high.
IPR enforcement	IPR enforcement is defined as the rights awarded by a society to individuals or organizations over inventions, literary and artistic works, and symbols, names, images, and designs used in commerce. They are said to give the titleholder the right to prevent others from making unauthorized use of their property for a limited period.

Source: World Bank Group, "ICTs at a Glance tables – Definitions and Sources", 2002. Available at: http://www.worldbank.org/data/countrydata/ictnotes.htm. OECD, Oslo Manual, "The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data.", Paris, OECD, 1997. World Intellectual Property Organization (WIPO), "What is a trademark?", 2003. Available at: http://www.wipo.int/about-ip/en/index.html? wipo_content_frame=/about-ip/en/trademarks.html. SearchCIO.com, glossary, 2003. Available at: http://searchcio.techtarget.com/glossary/ 0,294242,sid19,00.html. SearchSecurity.com, glossary, 2003. Available at: http://searchsecurity.techtarget.com/glossary/0,294242,sid14,00.html.

ANNEX TABLE 12. ICT POLICY INDICATORS

Indicator	Definition
National ICT strategy	The existence and development of an ICT national plan.
ICT plan of action	The existence and development of an ICT plan of action.
National initiatives	The presence of national introductory steps related to ICT.
Existence of technology incubator	In the business world, an incubator is an enterprise that is set up to provide office space, equipment, and sometimes mentoring assistance and capital to new businesses that are just getting started.
Planned technology incubator	Number and existence of planned technology incubators.
Operational technopole initiative	"Technology park" is used to describe a variety of efforts to stimulate the development of "entrepreneurial, knowledge-based small and medium-sized enterprises" (or SMEs) within a country. The term has at least 16 synonyms, with the most common being "science park", "research park", and "technopole".
Plan of technopole initiative	The presence of a plan of technopole initiative.

Source: American University, "What is a Technology Park?". 2001. Available at: http://www.american.edu/carmel/ab5293a/Whatis/whatis.htm. SearchWebservices.com, glossary, 2003. Available at: http://searchwebservices.techtarget.com/glossary/ 0,294242,sid26,00.html.

ANNEX TABLE 13. INDICATORS RELATED TO WIPO TREATIES

Indicator	Definition
World Trade Organization (WTO) member	WTO is the only global international organization dealing with the rules of trade between nations. At its heart are the WTO agreements, negotiated and signed by the bulk of the world's trading nations and ratified in their parliaments. The goal is to help producers of goods and services, exporters, and importers conduct their business.
Paris Convention	Refers to the Paris Convention for the Protection of Industrial Property.
Madrid Agreement	Madrid Agreement for the Repression of False or Deceptive Indications of Source on Goods.
Hague Agreement	The Hague Agreement concerning the international registration of industrial designs adopted by the diplomatic conference on 2 July 1999.
WCT	Defined as the WIPO Copyright Treaty adopted in Geneva on 20 December 1996.

ANNEX TABLE 13 (*continued*)

Indicator	Definition
PCT	Refers to the Patent Cooperation Treaty done at Washington on June 1970, amended on September 1979, modified on February 1984, and October 2001.
TLT	TLT stands for the Trademark Law Treaty adopted at Geneva on 27 October 1994.
PLT	Refers to the Patent Law Treaty adopted at Geneva on 1 June 2000.
Nairobi Treaty	Nairobi Treaty on the Protection of the Olympic Symbol adopted at Nairobi on 26 September 1981.
TRIPS	TRIPS stands for Trade Related Aspects of Intellectual Property Rights. The TRIPS agreement is described in the appendix 1C of the World Trade Organization Agreement from 1995. It permits virtually the globalization of patents and trademarks. It is said to grant companies the right to protect their patents in all the WTO member countries.

Source: World Intellectual Property Organization (WIPO), "What is a trademark?", 2003. Available at: http://www.wipo.int/about-ip/en/index.html?wipo_content_frame=/about-ip/en/trademarks.html.

ANNEX TABLE 14. CONNECTIVITY STATUS INDICATORS

Indicator	Definition
Leased lines	A leased line is a telephone line that has been leased for private use. A leased line is usually contrasted with a switched line or Dial-Up line.
ISDN lines	ISDN (Integrated Services Digital Network) is a set of CCITT/ITU standards for digital transmission over ordinary telephone copper wire as well as over other media. Home and business users who install an ISDN adapter (in place of a modem) can see highly graphic Web pages arriving very quickly (up to 128 Kbps). ISDN requires adapters at both ends of the transmission so your access provider also needs an ISDN adapter. ISDN is generally available from your phone company in most urban areas in the United States and Europe.
DSL lines	DSL (Digital Subscriber Line) is a technology for bringing high-bandwidth information to homes and small businesses over ordinary copper telephone lines.
Cable	Coaxial cable is the kind of copper cable used by cable TV companies between the community antenna and user homes and businesses. Coaxial cable is sometimes used by telephone companies from their central office to the telephone poles near users. It is also widely installed for use in business and corporation Ethernet and other types of LAN.
Regional satellite	A satellite is a specialized wireless receiver/transmitter that is launched by a rocket and placed in orbit around the earth.
Regional fibre optic connection	Fibre optic (or "optical fibre") refers to the medium and technology associated with the transmission of information as light impulses along a glass or plastic wire or fibre. Fibre optic wire carries much more information than conventional copper wire and is far less subject to electromagnetic interference.

Source: SearchNetworking.com, glossary, 2003. Available at: http://searchnetworking.techtarget.com/glossaryPage/ 0,294242,sid7,00.html.

Annex III

SELECTED R AND D INDICATORS AND DATA[**]

Some of the most commonly used indicators of R and D activity cover quantitative inputs, namely the number of scientists employed in R and D departments, expenditure per project and per researcher, overall investment in the purchase of new equipment and in building new facilities, and time allocated for a project completion. On the output side, the preference for indicator usage varies among countries.

The prevailing tendency in ESCWA member countries is to evaluate results of R and D in terms of expected savings achieved through improved products and processes. Some efforts have been devoted to grade the R and D output in terms of conformity with planning parameters and initial expenditure, and time-to-delivery estimates. Nevertheless, the limitation of these methods has been the lack of indicators to measure the quality of the final product.

Information on National S and T policy or strategic plans and related institutions:

(a) Major components, themes and areas of focus, short and medium-term objectives;

(b) Numerical targets and dates set in relation to resource allocations from GDP;

(c) National legislative and regulatory framework for R and D institutions/activities;

(d) Methodologies worked out for securing resources and following up on progress;

(e) Existence and orientations of bodies engaged in technology scanning and assessment at national/sectoral levels; date established and details of their linkages and operating methodologies;

(f) Number of R and D institutional units, their missions, affiliations and distribution over principal areas of R and D activity;

(g) Number of FTE (full-time equivalent) researchers and their distribution across R and D fields, by qualifications and type of institution (governmental, semi-governmental, private, and so on);

(h) Information on the existence, and extent of coverage and participation, in national information networks, as well as expenditure allocated to securing information as well as establishing linkages to other information networks/sources;

(i) Volume of total computing capabilities available to all R and D institutions and related activities across fields of activity and institution with information on generations and compatibility;

(j) Number of total support staff and their distribution across R and D institutions/units, R and D fields, as well as by qualification levels;

(k) Number of special R and D initiatives undertaken at the national level: aims, financial and other resources, cooperating bodies from industry, agriculture and the service sectors, as well as targets achieved;

(l) Initiatives and modes of assistance extended to businesses, concerning technology assessment and acquisition, with emphasis on the needs of small and medium enterprises;

[**] This section draws mainly on ESCWA's *Science and Technology Indicators: Basic Concepts, Definitions and Prospects for Development*, New York, 1997 (E/ESCWA/TECH/1997/6).

(m) Number of R and D publications across institution types, R and D fields, as well as publication/dissemination media, namely, local and international journals, as well as national, regional and international seminars, conferences and symposia;

(n) Availability, number and fields of activity of national technical facilities for R and D support, scientific equipment building and maintenance centres, laboratory equipment and materials manufacture/packaging facilities;

(o) Information on the activities of patent examination and patenting bodies and their linkages to R and D and higher educational institutions;

(p) Information on specialized R and D networks and special agreements for R and D collaboration and information/expert exchange within the country and with other countries/institutions.

ANNEX TABLE 15. NUMBER AND PERCENTAGE OF FTE RESEARCHERS BY R AND D AREA, AND THEIR DISTRIBUTION FOR EACH OF THE ARAB COUNTRIES IN 1996

	Agriculture		Health		Industry		Basic Science		Education		Engineering		Energy		Petroleum		Economy		Resource management		
Country	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	Total
Egypt	5 221	48.6	1 827	17.0	871	8.1	751	7.0	523	4.9	471	4.4	509	4.7	236	2.2	102	0.9	233	2.2	10 744
Morocco	756	46.5	69	4.2	223	13.7	161	9.9	190	11.7	89	5.5	75	4.6	0	0.0	48	3.0	15	0.9	1 626
Iraq	725	52.1	150	10.8	40	2.9	58	4.2	172	12.4	114	8.2	25	1.8	72	5.2	35	2.5	0	0.0	1 391
Algeria	217	21.6	98	9.8	109	10.9	114	11.4	116	11.6	133	13.2	110	11.0	83	8.3	24	2.4	0	0.0	1 004
Saudi Arabia	170	20.1	58	6.9	73	8.6	156	18.4	108	12.8	89	10.5	74	8.7	55	6.5	40	4.7	23	2.7	846
Sudan	311	48.4	68	10.6	115	17.9	44	6.8	33	5.1	31	4.8	25	3.9	0	0.0	16	2.5	0	0.0	643
Tunisia	215	44.3	65	13.4	8	1.6	26	5.4	45	9.3	55	11.3	0	0.0	21	4.3	50	10.3	0	0.0	485
Kuwait	102	23.2	20	4.5	41	9.3	17	3.9	27	6.1	17	3.9	69	15.7	38	8.6	34	7.7	75	17.0	440
Jordan	89	22.2	41	10.2	95	23.7	50	12.5	52	13.0	35	8.7	7	1.7	14	3.5	11	2.7	7	1.7	401
Syrian Arab Republic	124	34.8	30	8.4	13	3.7	15	4.2	39	11.0	112	31.5	20	5.6	0	0.0	3	0.8	0	0.0	356
Yemen	177	65.6	16	5.9	0	0.0	9	3.3	57	21.1	6	2.2	0	0.0	0	0.0	5	1.9	0	0.0	270
Libyan Arab Jamahiriya	83	35.3	17	7.2	16	6.8	27	11.5	28	11.9	10	4.3	26	11.1	16	6.8	12	5.1	0	0.0	235
Lebanon	63	30.7	32	15.6	4	2.0	45	22.0	22	10.7	14	6.8	12	5.9	0	0.0	8	3.9	5	2.4	205
Mauritania	47	40.5	11	9.5	18	15.5	16	13.8	22	19.0	0	0.0	0	0.0	0	0.0	2	1.7	0	0.0	116
United Arab Emirates	68	63.6	7	6.5	0	0.0	15	14.0	11	10.3	0	0.0	0	0.0	0	0.0	6	5.6	0	0.0	107
Bahrain	16	18.6	15	17.4	0	0.0	8	9.3	10	11.6	12	14.0	3	3.5	0	0.0	22	25.6	0	0.0	86
Oman	49	59.8	5	6.1	0	0.0	6	7.3	11	13.4	4	4.9	0	0.0	7	8.5	0	0.0	0	0.0	82
Qatar	0	0.0	0	0.0	2	5.9	8	23.5	13	38.2	4	11.8	0	0.0	0	0.0	5	14.7	2	5.9	34
Total	8 433	44.2	2 529	13.3	1 628	8.5	1 526	8.0	1 479	7.8	1 196	6.3	955	5.0	542	2.8	423	2.2	360	1.9	19 071

Source: ESCWA-UNESCO, *Research and Development Systems in the Arab States: Development of Science and Technology Indicators*, 1998 (E/ESCWA/TECH/1998/3).

ANNEX TABLE 16. DISTRIBUTION OF R AND D UNITS BY R AND D AREA AND COUNTRY 1996

Sector	Egypt	Saudi Arabia	Jordan	Morocco	Algeria	Syrian Arab Republic	Sudan	Tunisia	Iraq	Kuwait	Lebanon	Libyan Arab Jamahiriya	Yemen	Mauritania	Oman	Qatar	United Arab Emirates	Bahrain	Palestine	Total
Agriculture	12	8	2	4	2	6	2	2	4	2	1	1	3	2	1	1	1	0	1	55
Industry	13	4	4	3	2	0	2	1	1	5	1	0	0	0	0	1	0	0	0	37
Health	15	4	2	1	2	0	2	3	0	0	4	0	0	1	0	0	0	0	0	34
Marine science	2	2	1	1	2	2	1	1	1	1	1	1	1	1	1	0	1	1	0	21
Water and irrigation	1	3	1	1	1	1	1	2	1	1	0	0	1	0	1	0	1	1	0	17
Environment	1	0	3	1	0	1	2	0	1	1	0	0	0	1	0	1	1	1	1	15
Single comm.	1	5	0	0	1	0	1	2	1	0	0	1	0	0	1	0	1	0	0	14
Atomic energy	2	2	1	1	3	1	1	0	0	1	1	1	0	0	0	0	0	0	0	14
Engineering	4	4	0	1	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	13
Petroleum and petrochemicals	1	3	0	0	3	0	1	1	1	1	0	1	0	0	1	0	0	0	0	13
Education	1	3	1	0	0	1	0	0	0	0	0	1	1	0	1	2	0	0	0	11
Management and resources development	2	2	0	1	0	0	2	1	1	0	0	0	1	0	0	0	0	1	0	11
Renewable energy	0	1	0	2	1	1	1	1	1	0	1	1	0	0	0	1	0	0	0	11
Basic science	0	3	0	2	1	2	0	0	0	0	2	0	0	0	0	0	0	0	0	10
Geology and Mineralogy	1	1	2	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7
Biotechnology	2	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	6
Space and remote sensing	1	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Forestry	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	5
Food technology	2	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	5
Electronics	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Nutrition	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	3
Computer technology	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Electricity	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Chemical industry	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Building Construction	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
Total	64	49	24	23	22	22	18	16	15	15	11	7	7	6	6	6	5	4	2	322

Source: ESCWA-UNESCO, *Research and Development Systems in the Arab States: Development of Science and Technology Indicators*, 1998 (E/ESCWA/TECH/1998/3).

ANNEX TABLE 17. R AND D EXPENDITURE AND NUMBER OF FULL-TIME EQUIVALENT RESEARCHERS AND SUPPORT STAFF IN 1996

Country	R and D expenditure (millions of US dollars)	Number of FTE researchers	Number of FTE researchers per 100 000 population	Number of R and D support personnel	Number of R and D support personnel per 100,000 population	Ratio of R and D expenditure to the number of FTE researchers (thousands of US dollars)
Bahrain	3.74	86	14.3	57	9.5	43.4
Kuwait	67.11	440	25.9	690	40.6	152.5
Oman	10.76	82	3.7	300	13.6	131.2
Qatar	5.46	34	5.7	40	6.7	160.6
Saudi Arabia	196.09	846	4.6	1 575	8.5	231.8
United Arab Emirates	10.89	107	4.5	206	8.6	101.7
Egypt	227.50	10 744	17.6	26 329	43.2	21.2
Iraq	27.57	1 391	6.9	1 449	7.1	19.8
Jordan	20.62	401	9.1	1 070	24.3	51.4
Lebanon	7.45	205	6.6	239	7.7	36.4
Syrian Arab Republic	24.18	356	2.4	1 749	12.0	67.9
Yemen	10.30	270	1.7	771	4.9	38.1
Total	611.67	14 962	10.3	34 475	23.7	40.9

Source: Adapted from ESCWA-UNESCO, *Research and Development Systems in the Arab States: Development of Science and Technology Indicators* (E/ESCWA/TECH/1998/3).

Annex IV

SELECTED DATA ON HIGHER EDUCATION

ANNEX TABLE 18. NUMBER OF HIGHER EDUCATION STUDENTS IN THE ESCWA MEMBER COUNTRIES*

Country	1997	1998	1999	2000	2001
Bahrain	9 036	12 671	14 764	16 241	18 892
Egypt	1 161 961	1 312 438	1 447 489	..	..
Iraq	257 278	266 505	..	..	..
Jordan	113 364	118 803	123 891	135 520	146 401
Kuwait	18 243	17 937	17 940	17 794	17 997
Lebanon	87 957	87 330	101 440	103 869	119 487
Oman	9 444	10 408	11 304	12 416	14 351
Palestine	50 775	56 726	66 282	71 207	80 543
Qatar	8 475	8 424	8 476	8 893	8 462
Saudi Arabia	352 935	399 231	459 536	103 957	..
Syrian Arab Republic	237 475	226 951	252 845	257 749	290 975
United Arab Emirates	14 104	14 911	15 217	..	..
Yemen	104 323	135 768	155 537	147 181	..

Source: ESCWA, *Statistical Abstract of the ESCWA Region*, 2002 (E/ESCWA/STAT/2002/6)

* Higher education institutions include university and other higher education institutions.

ANNEX TABLE 19. UNIVERSITY GRADUATES IN THE ESCWA MEMBER COUNTRIES**

Country	1997	1998	1999	2000	2001
Bahrain	1 974	2 455	2 193	2 467	2 801
Egypt	158 285	199 841	247 884	..	..
Iraq	..	..	..	..	..
Jordan	13 595	15 557	18 010	20 018	19 989
Kuwait	2 989	2 870	2 882	2 968	3 023
Lebanon	11 422	11 298	12 895	14 742	..
Oman	735	869	1 008	1 124	1 071
Palestine	5 600	6 323	8 380	9 598	..
Qatar	1 391	1 341	1 407	1 435	1 453
Saudi Arabia	42 370	52 148	..	..	..
Syrian Arab Republic	14 280	17 015	17 009	16 635	16 755
United Arab Emirates	1 656	2 305	2 291	..	..
Yemen	5 048	11 156	13 001	16 217	..

Source: ESCWA, *Statistical Abstract of the ESCWA Region*, 2002 (E/ESCWA/STAT/2002/6).

** Most recent statistics are available for university graduates only and not graduates of all higher education institutions.

Annex V

VARIOUS DATA FOR SELECTED COUNTRIES

ANNEX TABLE 20. VARIOUS ICT INDICATORS FOR THE ARAB REGION

Country/region	Main telephone lines per 100 inhabitants 2002	Cellular subscribers per 100 inhabitants 2002	Personal computers per 100 inhabitants 2002	Internet users per 100 inhabitants 2002	Top-level domain names per 10,000 inhabitants 2002
Bahrain	26.31	58.33	16.04	24.7466	26.41
Kuwait	20.77	38.59	11.96	8.7913	15.11
Oman	8.97	12.37	3.24	4.5749	17.83
Qatar	28.94	43.72	18.03	8.2787	2.8
Saudi Arabia	14.48	11.33	6.27	6.9384	6.41
United Arab Emirates	34.18	75.88	13.55	36.738	163.54
GCC countries	16.92	21.30	7.57	10.19	23.75
Egypt	10.36	6.72	1.55	0.9295	0.47
Iraq	..	..	..	..	0
Jordan	12.76	16.71	3.28	4.5156	7.72
Lebanon	19.88	22.7	8.05	11.713	21.08
Palestine	8.64	9.26	..	2.3155	-
Syrian Arab Republic	10.3	1.2	1.63	0.3612	0.01
Yemen	2.24	0.81	0.2	0.0901	0.06
Non GCC countries	9.43	6.07	1.66	1.30	1.43
Algeria	6.1	0.96	0.71	1.60	0.26
Djibouti	1.54	2.29	1.52	0.69	7.59
Eritrea	0.9	..	0.25	0.23	2.16
Libyan Arab Jamahiriya	10.93	0.90	..	0.36	0.13
Mauritania	1.19	9.16	1.03	0.37	0.29
Morocco	3.8	20.91	1.37	1.69	0.90
Somalia	..	..	..	..	0.00
Sudan	2.06	0.59	0.92	0.26	0.00
Tunisia	12.23	4.01	2.63	5.15	0.35
ESCWA member countries	19.45	25.27	10.93	6.67	10.71
Arab World	13.47	17.69	6.72	4.57	7.04
World	18.04	18.77	9.22	9.72	238.26

Sources: ITU World Telecommunication Indicators Database, 6th edition, 2002; and International Telecommunication Union (ITU), "Arab States Telecommunication Indicators", 2000. Available at: http://www.itu.int/ITU-D/ict/statistics/at_glance/ARTI00_E.pdf.

ANNEX TABLE 21. TECHNOLOGY ACHIEVEMENT INDEX AND MEAN YEARS OF SCHOOLING FOR SELECTED COUNTRIES

	HDI rank	TAI rank		TAI		Mean years of schooling (age 15 and above)		
	2002	2001	Country	2001	1970	1980	1990	2000
High human development	22	18	Israel	0.514	8.1	9.4	9.4	9.6
	26	33	Cyprus	0.386	5.2	6.5	8.7	9.2
	38	37	Chile	0.357	5.7	6.4	7	7.6
	39		Bahrain		2.8	3.6	5	6.1
	45		Kuwait		3.1	4.5	5.8	6.2
	46		United Arab Emirates					
	51		Qatar					
High human development average					7.6	8.9	9.4	9.9
Medium human development	64		Libyan Arab Jamahiriya					
	75		Lebanon					
	71		Saudi Arabia					
	78		Oman					
	85		Turkey		2.6	3.4	4.2	5.3
	99		Jordan		3.3	4.3	6	6.9
	97	51	Tunisia	0.255	1.5	2.9	3.9	5
	108	56	Syrian Arab Republic	0.24	2.2	3.7	5.1	5.8
	106	58	Algeria	0.221	1.6	2.7	4.3	5.4
	115	57	Egypt	0.236		2.3	4.3	5.5
	123		Morocco					
Medium human development average						4.1	5.1	
Low human development	144		Yemen			0.3	1.5	
	149		Djibouti					
	139	71	Sudan	0.071	0.6	1.1	1.6	2.1
	152		Mauritania				2.4	
Low human development average						1.8	2.8	
World average						5.2	6	
Arab states average						..	..	..

Key:
- ESCWA member countries
- Arab countries
- Other countries

Sources: Adapted from UNDP *Human Development Report 2001*, Making New Technologies Work for Human Development, New York, Oxford University Press, Inc., 2001. *Human Development Report 2002*, Deepening Democracy in a Fragmental World, New York: Oxford University Press, Inc., 2002.

ANNEX TABLE 22. DIFFUSION OF TECHNOLOGY IN AGRICULTURE AND MANUFACTURING FOR SELECTED COUNTRIES

	HDI rank	TAI rank	Country	Fertilizer consumption (kg per hectare of arable and permanently cropped land)		Tractors in use (per hectare of arable and permanently cropped land)		Low-technology exports (as percentage of total goods exports)		Medium-technology exports (as percentage of total goods exports)		High-technology exports (as percentage of total goods exports)	
	2002	2001		1970	1998	1970	1998	1980	1999	1980	1999	1980	1999
High human development	22	18	Israel	140.1	277.1	40	56.1		12		16		29
	26	33	Cyprus	120.9	143	27.2	118.9	32	24	12	11	2	12
	38	37	Chile	31.6	194.6	8.3	23.5		3		5		1
	39		Bahrain		100		2		4		5		
	45		Kuwait		300	9	11.7		1		6		
	46		United Arab Emirates		390.1	11.7	3.4						
	51		Qatar		58.8	25	4.4						
High human development average				97.1	114.6	28.7	40.2	17	13	36	37	10	22
Medium human development	64		Libyan Arab Jamahiriya	6.2	23.8	1.9	16.1		2		2		
	75		Lebanon	135.4	196.4	7.7	18.2						
	71		Saudi Arabia	3.3	84.1	0.4	2.5		1		5		
	78		Oman		95.2	0.9	2.4		3		11		2
	85		Turkey	15.7	80.9	3.8	32.4		47		20		7
	99		Jordan	8.7	60.1	8.8	12.3						
	97	51	Tunisia	7.6	24.7	4.7	7.2	20	52	10	16		3
	108	56	Syrian Arab Republic	6.8	60	1.5	17	4	6	2	1		
	106	58	Algeria	16.3	11.7	5.9	11.4				1		
	115	57	Egypt	131.2	337.2	6.1	27.3		24		7		2
	123		Morocco	11.7	35.1	1.4	4.3	11	22	3	12		
Medium human development average				24.4	118.1	2.2	8.7		21		19		19
Low human development	144		Yemen	0.1	13.5	1.2	3.6	10		32		2	
	149		Djibouti										
	139	71	Sudan	2.8	2.2	0.4	0.6		2				
	152		Mauritania	1.1	4.2	0.4	0.8						
Low human development average				4.5	28.8	0.5	2.6						
World average				50.1	105.4	12.3	18.6		15		33		22
Arab states average				16.6	44.9	2.6	7.4		10		7		1

Key:
- ESCWA member countries
- Arab countries
- Other countries

Sources: Adapted from UNDP, *Human Development Report 2001*, Making New Technologies Work for Human Development, New York, Oxford University Press, Inc., 2001. *Human Development Report 2002*, Deepening Democracy in a Fragmental World, New York: Oxford University Press, Inc., 2002.