INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) DEVELOPMENT INDICES

World Summit on Information Society

Geneva
January 2003

UNCTAD/ITE/TEB/MISC.2 (VOL. III)

Prepared by the UNCTAD Secretariat
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<th>Full Form</th>
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<tr>
<td>CEE</td>
<td>Central and Eastern Europe</td>
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<tr>
<td>CSTD</td>
<td>Commission on Science and Technology for Development</td>
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<td>CU</td>
<td>'Catching Up' / 'Falling Behind'??</td>
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<td>EIU</td>
<td>Economist Intelligence Unit</td>
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<td>EU</td>
<td>European Union</td>
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<td>FDI</td>
<td>Foreign Direct Investment</td>
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<tr>
<td>GA</td>
<td>'Getting Ahead'</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GIT</td>
<td>Georgia Institute of Technology</td>
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<td>HDI</td>
<td>Human Development Index (UNDP)</td>
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<tr>
<td>HDR</td>
<td>Human Development Report (UNDP)</td>
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<td>HTI</td>
<td>High Technology Indicators (GIT)</td>
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<td>ICTs</td>
<td>Information and Communication Technologies</td>
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<td>IP</td>
<td>Internet Protocol</td>
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<td>ISP</td>
<td>Internet Service Providers</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>ITU</td>
<td>Information and Telecommunication Union</td>
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<td>IX</td>
<td>Internet Exchange points</td>
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<td>KU</td>
<td>'Keeping Up'</td>
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<td>LAC</td>
<td>Latin America &amp; Caribbean</td>
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<tr>
<td>MAE</td>
<td>Metropolitan Area Exchanges</td>
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<td>MNC</td>
<td>Multi-National Corporation</td>
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<td>NAPs</td>
<td>Network Access Points</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Cooperation and Development</td>
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<tr>
<td>PC</td>
<td>Personal Computer</td>
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<tr>
<td>PTO</td>
<td>Public Telephone Operator</td>
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<td>SSA</td>
<td>Sub-Saharan Africa</td>
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<td>UNCSTD</td>
<td>United Nations Commission on Science and Technology for Development</td>
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<td>UNCTAD</td>
<td>United Nations Conference on Trade and Development</td>
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<td>UNDP</td>
<td>United Nations Development Program</td>
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<td>UNIDO</td>
<td>United Nations Industrial Development Organization</td>
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<tr>
<td>WAP</td>
<td>Wireless Access Protocol</td>
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EXECUTIVE SUMMARY

BACKGROUND
This report has arisen out of work that was first undertaken by the United Nations Conference on Trade and Development (UNCTAD) for the Commission on Science and Technology for Development (CSTD) – [if you consider it to be substantially different].
This report was prepared by the United Nations Conference on Trade and Development (UNCTAD) for the Commission on Science and Technology for Development (CSTD).
It was first presented to the CSTD Panel Meeting in Geneva on 22 May - 24 May 2002, as part of the work programme for the inter-sessional period 2001-2003: “Technology development and capacity-building for competitiveness in a digital society”.

[WHAT THIS REPORT SETS OUT TO ACHIEVE]
This report seeks to analyse and evaluate Information and Communication Technology (ICT) development using indicators of ICT diffusion across countries. It develops a conceptual framework and selects key indicators measuring development in ICTs, with a specific focus on ICTs as pervasive technologies of global impact, wide application and growing potential. This study benchmarks levels of ICT development, in existing infrastructure connectivity, as well as measures of future potential and important determinants affecting countries' abilities to absorb, adopt and make use of these new technologies.

The challenges in such a benchmarking exercise are manifold, in the selection of a representative set of indicators measuring the complex concept of technology development; in the trade-off of 'breadth versus depth' in the nature and number of these indicators; and in the integration of the results of benchmarking into policy analysis. And yet, used wisely and with caution, benchmarking can provide useful information and meaningful analysis for policy purposes. Such a cross-country analysis permits comparison between countries and monitoring of progress over time. Comparison with better-performing countries helps identify policies for further improvement and progression. Although benchmarking cannot investigate causation, it nevertheless allows more straightforward identification based on evidence of 'success stories' for closer investigation for policy conclusions. Approached with thought, benchmarking is a useful input to policy analysis in allowing more informed and insightful study into policy and ultimately, in promoting better, faster and more effective ICT development.

[WHAT THIS REPORT DOES]
In conjunction with CSTD, UNCTAD reviewed and evaluated existing work to measure ICT development from different sources, including academia, the private sector and international organizations (UNDP, UNIDO, OECD and the ITU). On the basis of this work, UNCTAD constructed a theoretical framework to approach ICT measurement, comprising indicators for connectivity, access, usage and policy.

UNCTAD benchmarked and analysed the diffusion of ICT capabilities across 160-200 countries for 1995-2002. This cross-country study compiles data and calculates ICT Development Indices for: connectivity (physical infrastructure for ICTs, in penetration rates of Internet hosts, PCs, telephone mainlines, mobile phones per capita); wider access to ICTs (literacy, GDP per capita and cost of local calls, as well as actual number of Internet users); usage of ICTs (incoming and outgoing telecoms traffic, as an alternative to Internet data traffic flows in the absence of publicly available statistics on these); and policy environment
(a wider policy framework conducive to the adoption and absorption of ICTs, which can be evaluated in terms of the presence of a domestic Internet exchange, as well as competition in the local loop, domestic long distance and ISP markets). This study analysed country and regional rankings based on these index measurements, and reviewed results over time to identify interesting trends. It further sought to evaluate the extent and evolution of the digital divide, using basic measures of hardware equipment and numbers of Internet users in each country, to determine whether and in what way the digital divide is evolving.

[CONCLUSIONS]
Classification of countries as 'falling behind', 'keeping up' and 'getting ahead' on the basis of country rankings show stable rankings over time, with strong regional influences. As a generalisation, African and South Asian countries were classified as 'falling behind', Latin American and transition economies as 'keeping up' and OECD countries and S.E. Asian Tigers as 'getting ahead'. However, this masks considerable diversity in individual country experience, with Arab and 'island states' as notable successes having good connectivity despite less competitive policy measures. Strong positive correlations are observed between connectivity and access and, to a lesser extent, connectivity and competitive telecoms policy. Country rankings are stable and consistent over time, and in line with expectations based on income. Such stability is consistent with long-term time horizons required for telecommunications investment. It also implies that these Indices are based on indicators measuring central ICT development.

UNCTAD further analysed and measured the international digital divide in inequality in distributions of hardware equipment and Internet users across countries, using Gini measures of inequality. Trends in connectivity over time suggest that, despite stable country rankings, there is reducing inequality and potential convergence in the distributions of hardware across countries, yielding the intriguing result of a diminishing digital divide. Gini analysis reveals some small change in inequality, with only small, incremental reductions from highly unequal levels. Our results show that more recent technologies such as the Internet (as measured by Internet hosts and Internet users) are more unevenly distributed relative to older technologies, such as fixed line telephony. Our findings demonstrate 'leapfrogging' in mobile telephony (with lower levels of inequality, which reduce the fastest), suggesting greater potential for mobiles as more equally distributed technologies in bridging the digital divide.

However, Gini coefficients as relative measures across the whole distribution do not identify the origins of reducing inequality. UNCTAD therefore analysed relative movements in rankings to identify how countries and regions are faring in basic connectivity, to see which countries are contributing to reducing inequality, increasing inequality, or preserving the status quo. Based on a regional analysis of relative rankings, we find evidence that OECD countries are becoming more tightly bunched in the upper 'tail' of the distribution. Sub-Saharan African countries continue to occupy the lower tail of the distribution. The incremental reductions in Gini coefficient likely derive from the middle of the distribution of hardware equipment across countries. China in particular has a steady and substantial rise in relative rankings that influences the Gini coefficient strongly, since China is host to one fifth of the world's population. Taken together, it is envisaged that these relative measures of the digital divide and the insights derived from benchmarking, provide a more detailed picture of developments in the evolution in countries' ICT development.

Overall, these reductions represent only small, incremental reductions in inequality from their high levels of inequality. There is still considerable work to be done in bringing the
large majority of the world's population within reach of modern communications. And yet, the benefits of extending ICTs to the world's rural and poorer populations may be enormous. For then, truly, their voices may be heard.

1. INTRODUCTION

This report seeks to analyse and evaluate Information and Communication Technology (ICT) development using indicators of ICT diffusion across countries. It develops a conceptual framework and selects key indicators measuring development in ICTs, with a specific focus on ICTs as pervasive technologies of global impact, wide application and growing potential. This study benchmarks levels of ICT development, in extant infrastructure connectivity, as well as measures of future potential and important determinants affecting countries' abilities to absorb, adopt and make use of these new technologies.

In keeping with their complex nature and multiple applications, Information and Communication Technologies (ICTs) may be viewed in different ways. The World Bank defines ICTs as "the set of activities which facilitate by electronic means the processing, transmission and display of information" (Rodriguez & Wilson, 2000). ICTs "refer to technologies people use to share, distribute, gather information and to communicate, through computers and computer networks" (ESCAP, 2001). "ICTs are a complex and varied set of goods, applications and services used for producing, distributing, processing, transforming information – [including] telecoms, TV and radio broadcasting, hardware and software, computer services and electronic media" (Marcelle, 2000). ICTs represent a cluster of associated technologies defined by their functional usage in information access and communication, of which one embodiment is the Internet. Hargittai (1999) defines the Internet technically and functionally: "The Internet is a worldwide network of computers, but sociologically it is also important to consider it as a network of people using computers that make vast amounts of information available. Given the two [basic] services of the system – communication and information retrieval – the multitude of services allowed… is unprecedented". ICTs, represented by the Internet, deliver "at once a worldwide broadcasting capability, a mechanism for information dissemination, a medium for interaction between individuals and a marketplace for goods and services" [Kiiski & Pohjola (2001)].

ICTs have been in use for some time, for example, in voice communications technology. However, recent advances such as the Internet are breaking new ground (and introducing new divisions) in the achievements and potential they offer. Cukier (1998) notes that definition of the Internet "is very relevant to the peering debate [about the exchange of data traffic and interconnection agreements] as well as whether regulators [have] a role to play in Net matters". He points out that "the voice telecoms network is founded upon the principle of universal connectivity… The Internet, however, lacks a specific definition and it is uncertain whether the telephony model applies to it". In this view, [spread of] the Internet has unique important characteristics differentiating it from older technologies, such as telephony. This view has important implications for countries' policy approaches and the way in which they seek to encourage, monitor and regulate ICT adoption, interconnection and, ultimately, access.
It may be easier to define what ICTs are not: ICTs are not a panacea for development or replacement for real world processes. If real world processes are flawed, deficient or absent, ICTs cannot make good these flaws or make up for these deficiencies. If a government process is bureaucratic, convoluted and subject to delays, moving it online may not make it any more efficient; and instant transmission may not necessarily make it any faster. If controls over financial systems are inadequate or missing, making systems electronic will not make them effective; and may in fact make it more difficult to trace the audit trail. This emphasizes the importance of having well-thought out, well-established, clear real world processes, before moving them online. In this view, ICTs can be an effective 'AND', rather than a substitute 'OR'.

ICTs may, however, reshape, re-organize and fundamentally restructure working methods, and ultimately, the sectors in which they are used. ICTs offer generic advantages of: efficiency and productivity gains; information-sharing, storage, and communication; faster knowledge-accumulation, dissemination and application; in support of the specific purposes for which they are used. ICTs also permit new, collaborative work methods, with their potential for networking. Communication and interaction between previously isolated agents pool their individually isolated resources, knowledge and experience to build a common knowledge base that all members can draw upon. ICTs can transform work and research methods by enabling group interactions based on central reserves of shared knowledge. The evidence suggests that we still stand at the threshold of what ICTs may achieve, and that collaborative networking methods will evolve further, as people learn to communicate, interact and work in new ways. This makes ICTs a very exciting 'AND', and one that may change the equation altogether.

Despite the undoubted benefits offered by ICTs, substantial barriers to the effective use of ICTs also exist, in both developed and developing countries. These barriers must be addressed to allow realisation of ICTs' full potential. Some barriers may be endemic (e.g. the generation gap, learning processes, and gaining experience in ICTs). Developing countries face additional barriers to effective ICT usage. In the E-Commerce Report (2001), UNCTAD notes that "in developing countries, [government agencies] will have to deal with problems of telecoms infrastructure, poor computer and general literacy, lack of awareness of the Internet and regulatory inadequacy, that also hinder other applications of the Internet there". (These obstacles are not uncommon in developed countries, with the European Union seeking to address some of these challenges). Technological gaps and uneven diffusion in technology are not new – "older" innovations such as telephony and electricity are still far from evenly diffused – but what may be unprecendented is the potential size of the opportunity costs and benefits foregone by failure to participate in the new "digital society". Growth in the use of ICTs is highly uneven. There are significant disparities in access to and use of ICTs in developing countries, which risk being left behind in the digital revolution. Developing countries risk being left further behind in terms of income, equality, development, voice and presence on an increasingly digitalised world stage. They must look forward prospectively, and participate actively in building technological capabilities to suit their needs. Technology itself also has a role to play in this. Just as technologies create them, new innovations offer ways of bridging technological divides. Connectivity can build on existing infrastructure or bypass traditional means with technologies such as wireless. The availability of free software is transforming the IT industry.

This report seeks to benchmark the extent of ICT development, as an important contribution and input to policy-making. Benchmarking is important in measuring outcomes (but not
causation) from policies, and in monitoring progress in ICT connectivity and access. Benchmarking allows comparisons between countries and indicates how well countries are doing compared to others in terms of their adaptation, mastery and development in ICTs. A standard selection of indicators against which countries are measured allows comparisons and initial policy conclusions, between countries and over time. Comparison with better-performing countries helps identify policies for further improvement and progression. Although benchmarking cannot investigate causation, it nevertheless allows more straightforward identification based on evidence of 'success stories' and 'laggards' for closer investigation, as an essential input to policy analysis.

ITU (2002) notes in its 2002 World Telecommunications Development Report that "over the last few decades, virtually every country has succeeded in improving its telecommunications sector. Thus, every country can show that its particular blend of policies has been successful. It is only by making international comparisons that it is possible to show which policies have been more successful than others… For this reason, an approach based on comparative rankings may be more meaningful than one that uses absolute growth rates". UNCTAD therefore uses a methodology based on relative rankings, rather than absolute scores. Indeed, with respect to ICTs, it is unclear what the reference points for absolute scores would be. In this paper, we adopt a comparative approach based on relative country rankings to identify countries that are making progress in ICT uptake, and those which are being left behind in the digital divide.

2. THEORETICAL FRAMEWORK & LITERATURE REVIEW

In conjunction with the United Nations Commission on Science and Technology for Development (UNCSTD), UNCTAD reviewed and evaluated existing work to measure ICTs from different sources, including academia, the private sector and international organizations (UNDP, UNIDO, OECD and the ITU).

Our review of existing work carried out to date to evaluate countries' ICT capabilities reveals a consistent underlying theoretical framework of indicators of connectivity, access, policy and usage across most studies, irrespective of the viewpoint from which they are written, as illustrated in Table 1 below. UNCTAD uses this theoretical framework, shown in Table 1, to approach the measurement of ICT development and adopts this framework in the formulation of the ICT Development Indices. This section provides a brief discussion of some of the main conceptual issues arising from a review of the literature on approaches towards the measurement of ICT development.
Table 1: Theoretical Framework for Measuring ICT Development

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<tbody>
<tr>
<td><strong>Perspective</strong></td>
<td>Tech. Development</td>
<td>General IT</td>
<td>Defence</td>
<td>Commercial</td>
<td>Commercial</td>
<td>Sociological</td>
<td>Telecoms</td>
</tr>
<tr>
<td><strong>Item measured</strong></td>
<td>ICT diffusion</td>
<td>Global Diffusion of Internet</td>
<td>IT capability</td>
<td>E-Readiness</td>
<td>E-Readiness</td>
<td>Networked</td>
<td>Internet Access</td>
</tr>
<tr>
<td><strong>1. Connectivity</strong></td>
<td></td>
<td>Pervasiveness; Connectivity Infrastructure.</td>
<td>Connectivity Infrastructure pricing</td>
<td>Connectivity (30%) fixed &amp; mobile, narrow band/broadband</td>
<td>Info Infrastructure Software &amp; Hardware</td>
<td></td>
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<tr>
<td>(physical capacity; infrastructure)</td>
<td></td>
<td>Pervasiveness; Connectivity Infrastructure.</td>
<td>Connectivity Infrastructure pricing</td>
<td>Connectivity (30%) fixed &amp; mobile, narrow band/broadband</td>
<td>Info Infrastructure Software &amp; Hardware</td>
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<tr>
<td><strong>2. Access</strong></td>
<td></td>
<td>Pervasiveness Geographical dispersion</td>
<td>Pervasiveness Access</td>
<td>Cost of access Affordability</td>
<td>Availability Affordability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(wider determinants of access)</td>
<td></td>
<td>Pervasiveness Geographical dispersion</td>
<td>Pervasiveness Access</td>
<td>Cost of access Affordability</td>
<td>Availability Affordability</td>
<td></td>
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<tr>
<td><strong>3. Policy environment</strong></td>
<td></td>
<td>Competition: Local loop, long distance; Internet exchange.</td>
<td>Organisational infrastructure</td>
<td>Depth of Development E-Leadership; E-Business Climate</td>
<td>Legal and Regulatory Env't (15%) Business Env't (20%)</td>
<td>Legal Environment: Telecom &amp; Trade policy</td>
<td>ISPs; Prices; Traffic</td>
</tr>
<tr>
<td><strong>4. Usage</strong></td>
<td></td>
<td>Sectoral Absorption Sophistication of use</td>
<td>Sophistication of usage Information Security</td>
<td>E-commerce (20%); consumer/business use; e-services (10%)</td>
<td>Content B2B education B2C Ecommerce;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional</td>
<td></td>
<td>Proximity to Tech. Frontier Human Capital Social/cultural infrastructure5%</td>
<td>E-commerce (20%); consumer/business use; e-services (10%)</td>
<td>Content B2B education B2C Ecommerce;</td>
<td>IT Sector ICT Training</td>
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<td></td>
<td></td>
<td>Indigenisation</td>
<td>Education/literacy</td>
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</table>
Conceptual Issues relating to ICT Indices

The theoretical model and selection of indicators determines the quality and predictive power of Indices. A good example of a comprehensive, well thought-out model embodying views on causation in Internet indices is the United Nation's Industrial Development Organization (UNIDO)'s Industrial Performance Scoreboard (2002). Conversely, the absence of, or deficiencies in, a model constrains and limits the scope of observations possible (e.g. Economic Intelligence Unit's E-Readiness indicators, which yield only limited policy insights, following the lack of a coherent theoretical framework). The selection of indicators has important consequences for the study's results and conclusions. The United Nations Development Program (UNDP) use a broad selection of technological indicators in their Technological Achievement Index (2001). UNDP's index for agriculture and manufacturing technologies has the advantage of enabling UNDP to characterise developing countries by technological criteria relevant to developing countries' industrial achievements. Inclusion of older innovations permits longitudinal comparisons over time back to 1970.

In this study, we opt for a more narrow, focused subset of ICT indicators. This has the effect of restricting the time period (from 1995 onwards; following Hargittai (1999), who notes that usage of the Internet only really became widespread after 1993). It also has the effect of restricting our country sample, depending upon the indicator. For connectivity, 200 countries have been assessed. For more advanced data, notably on usage of ICTs, sample is restricted to mostly OECD and South Asian countries. Standardised data for several regions are not available, with individual case studies detailing usage for different countries.

Selection of indicators also describes the 'breadth versus depth' trade-off. This trade-off describes how standardised data is not available in detail for a large number of countries. Press (1999) observes that "in tracking diffusion of the Internet, one must choose a balance between breadth and depth". He concludes that with a complex concept as the Internet, "an index may be more robust than a [single] indicator in measuring a qualitative concept" (Press, 1999, p.5). From a practical perspective, if a wide sample coverage is sought, then basic, standardised indicators must be chosen for the index. For more detailed indicators such as usage and ICT take-up statistics, specialised data is only available for a smaller subset of countries. Furthermore, this type of data is most likely to come from country case studies, rather than the high level, standardised data we present here. In the trade-off between 'breadth versus depth', this study opts necessarily for breadth in pursuit of its cross-country benchmarking exercise.

UNCTAD (1991) distinguishes between input, output and performance-related indicators for technology indicators as a whole. However, it is becoming increasingly unclear as to what extent this distinction still applies in respect of ICT indicators. Is a Personal Computer to be viewed as an input (e.g. as a necessary piece of equipment for dial-up Internet access), as an output (e.g. in regression analysis, which has sought to explain the diffusion of PCs, as in Caselli & Coleman, 2001), or as part of the phenomenon to be studied?

The distinction between input and output indicators (e.g. UNDP, 2001) finds a parallel in similar distinctions between ex ante and ex post indicators (e.g. World Economic Forum, 2001), and determinants and performance indicators (e.g. UNIDO, 2002). It also partly relates to views of technologies, including ICTs, as sequential, in which one technology forms a basis or input to another in predefined steps. For example, UNDP (2001) justifies
including telephones and electricity per capita as indicators in its Technological Achievement Index since “they are needed to use newer technologies and are pervasive inputs to a multitude of activities”. Alternatively, views of technologies may be synergistic, in which a cluster or spectrum of technologies is necessary as simultaneous inputs to an outcome technology e.g., electricity, laser technology, digital code, PC, modem for Internet access. The question of whether inputs into the process of technology development are considered sequential, as with UNDP (2001), or synergistic, as in the ‘cluster’ approach of McConnell International (2001), determines the form of index adopted – See 'Index Methodology' in the next Section.

Views of sequential and synergistic technologies also partly reflect views of causation. Indices are not capable of determining or quantifying causation, for which more sophisticated statistical techniques are required. These may be conceptually embodied in the theoretical framework, e.g. the UNIDO (2002) distinguishes between 'Determinants' and indicators of 'Industrial Performance' and investigates causation by methods including cluster analysis and regressions. Indices provide a ready means of measuring a standardised predetermined set of 'symptoms', rather than their wider 'causes'. There is likely to be significant endogeneity within this model, which indices are not equipped to analyse.

Furthermore, the indigenous nature of technology is a consideration for some studies. In Porter et al (1999)'s original Capacity for Innovation Index, the highest scores in its qualitative variable were assigned to countries where "companies obtain technology by pioneering their own new products and processes", whereas countries where "companies obtain technology exclusively from foreign countries" received less credit. This method values domestic innovation as more valuable than imported technology and diminishes the value of international technology transfer (TT), despite substantial evidence to the contrary, for the potential success of these channels (notably Asian NIEs, such as Korea). The World Economic Forum also distinguishes between domestic and foreign technology in its study of national competitiveness, on the basis that "evidence suggests that without strong domestic technological activity, heavy dependence on foreign technologies leads to limited and shallow technology transfer" (World Economic Forum, 2000). The Mosaic Group (1996) assesses 'indigenisation' in its IT Capacity Framework, defined as the national origins and staffing of technology with indigenous personnel. However, subsequently the Mosaic Group (1998) assesses worldwide diffusion of technology in its 'Global Diffusion' of the Internet framework as a stand-alone, independent package that countries can import and apply, and no longer considers the national origins of technology, R&D or human capital.

The question as to what extent it is still relevant to talk of the national origins of a global technology such as the Internet, is intriguing. The Economist Intelligence Unit notes that "the Internet is global, but local conditions matter" (EIU, 2001). "National" and cultural influences are apparent in the readiness with which consumers adopt new technology and issues of MNC operations and FDI in technology transfer. There is an important role for the state in the development of policy and the telecoms and business environment. Governments can influence access to technology (connectivity, control over access, censorship). Important policies include telecoms policy and regulation, import policy, FDI, MNCs and technology transfer, political openness/censorship, e-governance, E-Leadership, education, research, stable macro-fundamentals and the legal environment. This academic question finds its practical correlation in the adoption of national economies as the basic unit of analysis (see the next section: ICT Development Indices).
3. ICT DEVELOPMENT INDICES

The Index of ICT Diffusion is a simple arithmetic average of scores on quantitative variables (connectivity and access indices). Qualitative variables for policy indicators are also presented separately for 2001-2. The telecom usage index was also reviewed and analysed, but is not included, as it is unclear to what extent telecom traffic is representative of Internet use. These indicators represent a selective subset of the full set possible with other indicators were omitted owing to limited data availability or difficulties in their measurement.

Table 2: Construction of the ICT Development Indices

<table>
<thead>
<tr>
<th>Index/Dimension</th>
<th>Indicators</th>
<th>Sources</th>
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<tbody>
<tr>
<td>1. Connectivity</td>
<td>Internet hosts per capita</td>
<td>All data series from ITU</td>
</tr>
<tr>
<td></td>
<td>Number of PCs per capita</td>
<td>deflated by UNSD population data</td>
</tr>
<tr>
<td></td>
<td>Telephone mainlines per capita</td>
<td>and compared to World Bank data</td>
</tr>
<tr>
<td></td>
<td>Cellular subscribers per capita</td>
<td>for accuracy check.</td>
</tr>
<tr>
<td>2. Access</td>
<td>Internet users per capita</td>
<td>ITU</td>
</tr>
<tr>
<td></td>
<td>Literacy (% population)</td>
<td>UNSD</td>
</tr>
<tr>
<td></td>
<td>GDP per capita</td>
<td>World Bank</td>
</tr>
<tr>
<td></td>
<td>Cost of a local call</td>
<td>ITU</td>
</tr>
<tr>
<td>3. Policy</td>
<td>Presence of Internet exchange</td>
<td>UNCTAD research</td>
</tr>
<tr>
<td>(presented separately, as relates to 2001-2).</td>
<td>Competition in local loop telecoms</td>
<td>ITU</td>
</tr>
<tr>
<td></td>
<td>Competition in domestic longdistance</td>
<td>ITU</td>
</tr>
<tr>
<td></td>
<td>Competition in ISP market</td>
<td>ITU</td>
</tr>
<tr>
<td>Usage: Telecom Traffic (analysed separately, but not presented, as appears unrepresentative and not clear to what extent this reflects global diffusion of ICTs and Internet).</td>
<td>International incoming telecom traffic (minutes per capita)</td>
<td>ITU</td>
</tr>
<tr>
<td></td>
<td>International outgoing telecom traffic (minutes per capita)</td>
<td>ITU</td>
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Appendix 1 presents the ICT Development Indices and Index of ICT Diffusion and country rankings for 2001, 2000 and 1999 for all countries with data available. Indices and rankings for 1998 and 1995 have also been calculated and are analysed in Appendices 3 and 4.
Connectivity is narrowly defined as the physical infrastructure available to a country, as distinct from broader factors determining access (e.g. literacy, cost). Connectivity represents the basic 'limiting factor' on access to and use of ICTs – without the essential physical hardware, ICT use is not possible. We defined the narrow 'connectivity' as the minimum set of measures necessary for ICT access as comprising: Internet hosts per capita; PCs per capita; telephone mainlines per capita; and mobile subscribers per capita. This excludes supporting infrastructure (such as electrical supply and transport), affordability and broadband access, which may be currently more relevant to developed countries, but is expected to become increasingly important to all countries in the future. McConnell International note that "a multitude of factors must be in place... a weakness in any one can degrade a country's ability to take advantage of the economic potential of the Internet". This view sees connectivity as a cluster of technologies with synergies, rather than precedence, between different types of physical infrastructure. This is in contrast to UNDP's sequential logic of 'old' (telephony and electricity) as opposed to 'new' innovations (hosts, PCs) and "leapfrogging" between stages with a sequential order.

1. Internet hosts per capita

Number of internet hosts has been taken as a measure of the Internet penetration of a country, and the degree of national "connectivity". Network Wizards (NW) define a host as: "A domain name that has an IP address (A) record associated with it. This would be any computer system connected to the Internet (via full or part-time, direct or dialup connections) ie. nw.com, www.nw.com". OECD (1998a) considers that "host count is the most precise available data on the presence of Internet in a country". Cross-country regression work has mainly used this variable as the most representative variable of Internet diffusion e.g. Hargittai (1999), Kiiski & Pohjola (2001), Robinson & Crenshaw (2001).

Increasing number of Internet hosts implies increased ability to handle, service and store large amounts of data. However, difficulties include:

- ambiguity/overlap in definition with Internet server functions - Hosts may include name servers, mail servers and file servers;

- measurement methods and difficulties in allocating hosts to nations:

Hosts are assumed to be in the country shown by their country code (e.g. .nl for Netherlands). However, "there is not necessarily any correlation between a host's domain name and its location. A host with a .NL domain name could easily be located in the U.S. or any other country. Hosts under domains EDU/ORG/NET/COM/INT could be located anywhere. There is no way to determine where a host is without asking its administrator" (Network Wizards). This is a major problem, giving anomalous results e.g. the top country for Internet host penetration at July 1999 was the Pacific island Niue (Minges, 2001). The Solomon Islands had no hosts according to the July 1999 Networks Wizards survey, but has been connected to the Internet since 1996. The U.S. ranks 44th in Internet penetration based on the .us code. Most hosts in US use .com, .net or domains other than .us (Minges, 2001).
A single computer may host several domain names and a single domain name might be
hosted by a group of computers (Minges, 2001). These figures have been adjusted for
physical location of the hosts by ISC. Data are subject to revision and there are often
discrepancies between surveys. In July 1999, OECD nations owned 93% hosts (Press, 1999).

2. PCs per capita

Telephone lines and personal computers are key components for Internet access before
3Generation and WAP mobile access become widely available, with significant implications
for ICT adoption. Current access methods include dial-up access, using a telephone line, PC
and modem. PCs therefore represent an upper limit for Internet access. Caselli & Coleman
(2001) use number of computer imports as a measure of "computer technology adoption".

PC estimates are available for developed countries, but measurement may not be reliable.
Most ITU data are estimates of PC stocks from sales or import data. This is inaccurate for
developing countries, where shipment data are scarce and significant channels for PC imports
are omitted (e.g., smuggling, grey market, local assembly). Increased PC penetration rates
should increase ICT connectivity. This is purely a numerical count and gives no indication
of the power or quality of PCs, usage made of them, or method (e.g. shared Internet access).

3. Telephone mainlines per capita

This is a relatively reliable, basic 'limiting factor' of connectivity and representative of
potential, if not actual, levels of 'dial-up' access. ITU statistics include telephone subscribers
plus the number of pay phones (data from telecom authorities or operators). Increased
availability of telephone mainlines should increase connectivity, assuming dial-up access is
available. However, this does not give an indication of the speed, reliability or cost of the
connection, which are important considerations.

It is important to be aware of the proxy variables that may be implicit in this measure.
Telephone networks typically require large investments, so average national income and the
public resources available play a large role in determining connectivity on a national basis.
Population distribution, urban/rural dispersion and underlying geographical factors are
important determinants of the extent of telephone networks e.g. Nepal and Cambodia have
relatively limited mainline networks, while Turkey's is widely distributed.

4. Mobile subscribers per capita

This measure of mobile connectivity will become increasingly important in the future.
Current methods of Internet access emphasise PC-based applications, with 3G and WAP less
widely adopted. Inclusion of mobiles allows leapfrogging in e.g. Cambodia (ITU case study,
2002) to be counted. However, ITU notes that the Cambodian government has neglected
fixed lines, which are "more important for Internet access at this time". Inclusion of both
fixed and mobile telephones reflects forms of ICT access which are important both now and
in the future.
Jensen (2000) considers Internet connectivity from a more technical telecommunications perspective, noting that it "requires more than simply installing phone cables... the Internet is dependent on the telephone network ([comprising] cost of the line and cost of local and long-distance charges), availability and affordability of access equipment... and pervasiveness of telematics (mix of hard/software with human/organisational skills and knowledge transfer)". This introduces a broader definition of access and the factors determining use of ICTs, beyond narrow connectivity.

1. Number of Internet users

This is an ex post measure of the level of Internet usage achieved by a nation in realised access to the Internet. However, Nua surveys and Minges (2001) point out different survey methods and definitions of Internet 'users':

Inhabitants > awareness > ICT access > users > subscribers

Number of subscribers paying for Internet access is more precise than users and implies a certain degree of usage in terms of realised actual users. It is also more measurable, but may not reflect full usage as it omits free or shared access. For developing countries, subscribers may constitute 'elite' consumers and fail to include common types of usage (e.g. shared access and cybercafes).

Nua collects its data from national surveys that do not use consistent methodology, reducing their comparability. For consistency, we used ITU estimates of Internet users, weighted by population to yield Internet users per capita. ITU surveys were observed to be consistently lower than SangoNet surveys (Nua). However, to test how representative ITU surveys are, countries were scored and ranked according to Nua and ITU user estimates. Comparison of these rankings revealed relatively similar country profiles.

2. Literacy

In the absence of widely available voice protocols, text-based protocols remain the most widely used Internet applications. Language barriers and illiteracy have been identified as common obstacles to Internet access. Language has been modelled using dummy variables for English-speaking former colonies (Robinson & Crenshaw, 2001). However, the rapid growth of other languages on the Internet means that the importance of this obstacle to access is diminishing all the time. According to GlobalReach, 43% of online users and 68.4% Web content use English, down from 80% web-pages in English in the late 1990s. Literacy remains a pervasive barrier to access, particularly for developing countries. Basic literacy represents an important ex ante capability for Internet access, of which only a small subset may be realised as the proportion of Internet users. 'Depth' measures of human capital, such as tertiary education, are considered less relevant for basic Internet access. We have therefore included basic literacy in our index.
3. Cost of a local call

Prices are an important measure and determinant of access, since people will not use the Internet if they cannot afford it. In Europe, the practice of per minute billing has been considered a major obstacle to Internet adoption (Center for Democracy & Technology, 2002). Some countries may have high Internet connectivity (e.g. high telephone and PC penetration) but relatively low user levels. The most heavily used Internet access method is dial-up (U.S. Internet Council, 2000), which entails the following main charges:

1. telephone charges (line rental/call charges to PTO);
2. Internet access charges (paid to the ISP).

Internet pricing comparisons are complex (depending upon method of access, time and frequency of usage), change rapidly and are often only available for developed countries. Given data constraints for developing countries, we adopted cost of a local call as the most representative indicator of cost of access. However, issues with *telephone charges* include:

- local call charges: some telephone operators do not charge directly for local calls (includes operators in N. America and New Zealand) – this has been considered an integral factor in and key to the expansion of ICTs in North America (Information Society, quoted in Center for Democracy and Technology, 2002);
- operators may include a proportion of "free" local calls in subscription charges;
- charges may be fixed regardless of call duration;
- local call charges may differ depending on the time of day, day of week, or whether the call is for Internet access;
- operators may provide discounted calls to user-specified numbers.

Reduced cost of calls should facilitate the expansion of access to ICTs.

4. GDP per capita

Income is another key determinant of access and people's ability to afford hardware investment and ongoing call costs (that are often a significant proportion of the cost in accessing the Internet). $1 an hour charged by a cybercafe is unaffordable for people whose average income is $2 per day. Average national income is also a proxy variable for a country's level of development, often implicitly related to a country's level of investment and thus its connectivity and infrastructure. Kedzie (1997) notes that "economic development is a leading candidate for a compounding factor that affects both democracy and electronic communication networks simultaneously". However, in his study of democracy and interconnectivity based on simultaneous equations analysis growth in Internet nodes, "statistical test results do not support… economic development as a confounding third variable… neither democracy nor GDP proves to influence interconnectivity strongly".
3. Policy Index

The Policy Index relates to 2001-2, as this data is current and ITU gives 'realtime' data. Retrospective comparison is made with the other indices for 1995-2000. However, the stability of the rankings emerging (see section 4: Discussion of Results) give us confidence that these are valid comparisons to make.

1. Presence of Internet Exchanges

Abramson (2000) defines Internet exchange (IX) points – also called network access points (NAPs) or metropolitan area exchanges (MAEs) – as physical installations created by third parties to facilitate traffic exchange between ISPs. Telegeography defines IX as "services created to facilitate on-site interconnections between independent or third-party Internet networks". This definition can be ambiguous: ITU considers Egypt has access to the functions of an IX (ITU, 2001) but Egypt is not listed as having an IX (Telegeography).

Internet exchanges are important to permit domestic exchange of within-country traffic, without using valuable international bandwidth. Abramson (2000) notes that IX "provide focal points for local traffic exchange, enhancing local Internet infrastructure and reducing dependence on international links". Establishing an Internet exchange is an important policy decision in the allocation of resources for developing countries, keeping domestic Internet traffic within the country and saving international bandwidth for other uses.

For the majority of developing countries, Internet exchanges are nationally based i.e. one per country (e.g. Kenya IX, Indonesia IX). Some countries have multiple exchanges serving major urban centres [Capetown IX (CINX), Johannesburg IX (JINX)]. In U.S., IX operate primarily at the State level or serve major urban centres (MAE may be an appropriate name).

Our policy variable is a dichotomous variable (1 for an IX, 0 for its absence) since, for the majority of developing countries, presence of an IX is a major step. The additional benefits arising from further exchanges at the urban level may be considered marginal. The establishment of an IX may also be indicative of a proactive ICT policy outlook.

2. & 3. Competition in the local loop/domestic long distance

Competition in a country's telecoms sector is an important policy choice. Current thinking holds that monopolies may hinder rapid development and advocates liberalisation of the telecoms sector in promoting competition, lowering prices and expanding access. OECD (2001) concludes "countries that moved early to liberalise telecoms have much lower telecoms costs and a wider diffusion of ICTs than countries that were late to take action" (p.9). They recommend that countries "facilitate the diffusion of ICT, by increasing competition in telecoms and technology (p.22)... [with] policies to unbundle the local loop and improve interconnection frameworks" (p.24). The structure and policy developments in the telecoms market affect the diffusion and absorption of ICTs within a country.

Gorman & Malecki (2000) observe that "regulation and lack of telecommunication competition make it more expensive to operate through Asian and European providers
ICT Development Indices

(Bond, 1997; Cukier, 1998). The high cost of infrastructure and connections in Europe makes a circuit from Washington DC to Paris, London or Stockholm cost less than direct lines (Paltridge, 1999). Although prices are dropping as competition increases, leasing capacity on many intra-European leased lines remains more expensive than trans-Atlantic routes (Paltridge, 1999)

However, evidence from the cross-country regression studies is conflicting. Kiiski & Pohjola (2001) found that Internet access cost best explained growth in computer hosts per capita, however, competition (lack of monopoly) in telecoms markets proved insignificant. This is in sharp contrast with Hargittai (1999), who found that monopoly in the telecoms sector had a considerable negative impact on Internet connectivity in OECD countries (but not via reduced prices in access costs, which proved statistically insignificant).

Competition in the local loop describes a country's telecoms market structure and government policy towards telecoms, irrespective of whether competition actually results in reduced prices. Based on data from ITU T-Reg Unit, our index scores competition in the local loop as 1, partial competition 0.5, duopoly 0.25 and monopoly 0. It is important to be aware of the implicit value judgments inherent in this scoring system. The 'monopoly' score of 0 does not recognise the potentially beneficial effects conferred by a "benign monopoly". SingTel is widely recognised to have been an efficient, proactive incumbent in Singapore's telecoms sector, with important benefits for the adoption of ICTs in Singapore (ITU, 2001). This contrasts with Nepal Telecommunications Company in Nepal, which "was not customer-orientated in pricing, bandwidth or service" (ITU, 2000). In future work, the blunt monopoly/competition distinction could be replaced by country analysis of actual effects in practice.

4. Competition in the ISP market

ITU defines web servers as installations that provide end-user access to the Internet, disseminate information and sell products and services (Minges, 2001). However, Cukier (1998) identifies four different types of ISP (backbone, downstream, webhosting and online service providers). Competition in a country's ISP market is important for the domestic diffusion of ICTs. Competition in Internet service provision may reduce prices and installation time, improve quality and availability of different services and customer care, thereby enhancing access.

The importance of a vibrant ISP market is illustrated by Indonesia and Egypt, each with in excess of 60 ISPs, as opposed to Cambodia and Vietnam, where a limited number of ISPs and higher market concentration arguably result in higher prices and reduced customer service (ITU case studies).

Number of ISPs in a country has been used as an indicator of market liberalisation. However, there are at least four different types of ISP [Cukier (1998)], markets may be fast-changing and there may be no legal requirement for ISPs to register. It is also necessary to distinguish between licensed ISPs and operational ISPs. This makes ISP counts inaccurate in large, liberalised markets. Number of ISPs has not been used in our index. We used ITU's T-Reg unit data to define this variable as a simple dichotomous variable (competitive scored as 1, monopoly as 0), rather than the continuous number of ISPs.
4. Usage: Telecom Traffic (omitted from the Index of ICT Diffusion)

We investigated Internet traffic data. However, this data is commercially sensitive for Internet Service Providers (ISPs), who did not respond positively to our data requests. This is consistent with OECD (1998), who note an "absence of data on Internet traffic flows between countries". Abramson (2000) notes "meaningful Internet traffic statistics do not yet exist", despite widespread use of telephone traffic data. Minges (2001) notes that "Internet traffic data are scarce. Where available, they are compiled by telecom operators, ISPs, and some government agencies. Internet average daily usage in minutes reveal wide variations in average usage times across countries".

We investigated existing data on telecom traffic as an indicator of usage. Telephone technologies form part of the ICT technological cluster. They are however mature technologies with established uses and may not be representative of usage patterns for more recent Internet technologies. Our telecom index is calculated as the average of incoming/outgoing telecoms traffic (minutes per capita population):

\[ \text{Telecom traffic index} = \frac{\text{incoming traffic} + \text{outgoing traffic}}{2} \]

The results from our telecom index reveal the interesting phenomenon of 'offshore islands'. There is a small, but important, sub-category of 'island states' (such as Cayman Islands, Bahamas, Bermuda) specialised in service industries such as offshore banking/financial services, which require and are highly intensive in the use of ICTs. Renata Lebre La Rovere (1996) points out in her excellent review of Brazilian banking that "a bank's production process is particularly suited to benefit from IT diffusion, since it is organised around the storage and transfer of information". Banking particularly lends itself to automation and computerisation due to the high volume of repeat transactions involved. These economies have high PC and telephone penetration rates. However, their importance is apparent in the telecom usage statistics, where they have highest average incoming/outgoing telephone traffic. Please see discussion of results.

The extent to which this usage phenomenon is representative of Internet data traffic flows is questionable. Comparison of country rankings in telecom traffic with total Internet users (regardless of type of usage) reveals little similarity in country rankings. We have therefore kept this index separate and not included it in the Index of ICT Diffusion. However, current telecom traffic may demonstrate future patterns of usage of ICTs as these more recent technologies mature.
3.2. INDEX METHODOLOGY

Index Methodology

Edgeworth (1925) defines an index number as "a number [that] shows by its variations the changes in a magnitude which is not susceptible either [to] accurate measurement itself or [to] direct valuation in practice". Press (1999) observes that "in tracking diffusion of the Internet, one must choose a balance between breadth and depth" and concludes that "an index may be more robust than a [single] indicator in measuring a qualitative concept" (Press, 1999, p.5).

The Mosaic Group suggests that individual technologies need to be evaluated, since countries seldom exhibit uniform capabilities across the broad spectrum of ICTs. Measures of breadth and depth are needed; a dilemma which the Mosaic Group resolves by the use of Kiriat or 'wheel and spoke' diagrams [Kiriat, 1973] to reflect technology as a 'multi-faceted concept'. UNCTAD has reflected this balance between breadth and depth through use of an aggregate index with component sub-indices.

However, there are dangers inherent in the use of a disaggregated index. The Mosaic Group observes in their 'Framework Analysis' paper (1997) that "while it is tempting to derive a single index to reflect a country's IT capability, such an approach is unlikely to provide the depth of understanding needed for policy decision-making". Press (1997) explicitly warns against the dangers of averaging, or "reducing a [multi-faceted] capability diagram down to a single number" (i.e. area), since capability diagrams with the same total area may have very different shapes i.e. countries exhibit different profiles across the spectrum of ICT technological capabilities. Press (1999) notes further challenges for Internet indices: [they] "should be orthogonal, each measuring an independent aspect of the state of the Internet in a nation, but it is difficult to define indices that are both comprehensive and uncorrelated".

Simple averaging of indicators in an index implicitly assumes equal weighting of indicators and the possibility of offset of one indicator by another (i.e. connectivity is assumed equivalent to access and policy). GIT (2000) note that an "additive model implies that strength on any one of these dimensions could compensate for weakness on another".

The question of whether inputs into the process of technology development are considered sequential, as with UNDP (2001), or synergistic, as in the 'cluster' approach of McConnell International (2001), determines the form of index adopted. A sequential concept of technological inputs implies an additive model in which factors with implied equivalence may offset each other. In other words, strength on one aspect can compensate for weakness on another (GIT 2000). This is also the perspective within which the idea of 'leapfrogging' fits in. For instance, Cambodia's lack of fixed mainlines may not matter, as its high mobile penetration rate is likely to offset this, implying 'leapfrogging' by 'skipping a step' in the sequence.

Conversely, a synergistic view of a critical mass of associated technologies essential for a country's advancement in technology implies a multiplicative model in which weakness in any one input may hinder and impede effective development on the basis of non-equivalent inputs. This is the view put forward by McConnell International (2001) in the context of the Internet, in stating that a multitude of factors must be in place to take full advantage of the
economic potential of the Internet, and that the weakness in one area can seriously obstruct
the realisation of potential benefits. GIT (2000) also subscribe to a synergistic view by
highlighting that all four dimensions in their model, namely national orientation, socio-
economic infrastructure, technological infrastructure and productive capacity, have to be
strengthened in order for a nation to enhance its technology-based export competitiveness.
Despite these two differing views and methodologies, indices have usually followed simple
additive averaging models. We also opt for such a model for mainly two reasons. First, our
review of existing work to date indicated that results calculated using both methodologies do
not differ significantly from each other. Second, the additive model is more widely used due
to its relative simplicity.

In fact, determinants do not have the same or equivalent influence over IT capability.
Connectivity is a limiting factor, while government policy may result in lower IT capability
for a well-connected nation or different consequences for IT capability of equivalently
connected nations following different policy paths (e.g. Pakistan/India: positive impact of
eyear liberalisation of telecoms licenses for Internet growth in Pakistan, compared to slower
growth under public monopoly, private monopoly and finally liberal privatisation in India).

We have used the aggregated index approach, with component indices (similar to UNDP's
HDI). Countries' overall scores may be disaggregated into component indices of interest,
permitting finer discernment between nations with different profiles across the spectrum of
ICT capabilities. Attention should not focus on final index scores, but on scores across
country profiles.

Relative or Absolute Indices

ITU (2002) notes in its 2002 World Telecommunications Development Report that "over the
last few decades, virtually every country has succeeded in improving its telecommunications
sector. Thus, every country can show that its particular blend of policies has been successful".
In absolute scores, therefore, nearly all countries will show increases in telecommunications
connectivity. ITU concludes "it is only by making international comparisons that it is
possible to show which policies have been more successful than others… For this reason, an
approach based on comparative rankings may be more meaningful than one that uses
absolute growth rates". ITU argues that relative growth rates are more insightful for policy
analysis than absolute growth rates. UNCTAD therefore uses a methodology based on
relative rankings, rather than absolute scores. Using relative rankings, countries' index
scores are calculated as a proportion of the maximum score achieved by any country in any
one year (see next Section). This method has the advantage that reference points derive from
real-world achievements realised by any country (listed in Appendix 5). However, it has the
drawback that reference countries change year on year, reducing inter-year comparability.
Only country rankings can be compared between years, consistent with the ITU's
recommendations, rather than direct comparisons of countries' scores (since the reference
points are changing).

In this paper, we adopt a comparative approach based on comparisons of relative country
rankings between years to identify countries that are making progress in ICT uptake, and
those which are being left behind in the digital divide.
Evidence from other studies illustrates some issues that may arise using relative indices. GIT (2000) notes that relative indexing "is a relative scaling so that an apparent 'decline' over time or low score is only relative to other countries". GIT's HTI "are relative indicators. Hence, a 'decline' on an indicator does not imply an actual drop, just that competing countries have advanced faster". Thus, "Germany is considerably closer to other leading nations than to the U.S. and Japan… this distancing is not due to any decline in Germany, but rather to the remarkable gains by the U.S." (GIT 2000). UNIDO (2002) also notes that: "movements in rankings are relative, not absolute. Many [countries] like Kenya are not particularly technology-intensive exporters – they move up the scale because their exports are more complex than their other measures relative to other countries in their vicinity".

These observations support the idea that in general, it is more meaningful to talk about countries' rankings, rather than a country's index score. Countries tend to group or 'bunch' together (particularly around the centre of the index distribution), where a score interval of 0.1 may be equivalent to several places in the rankings. Conversely, countries that stand out in the lead or fall behind in the tails of the distribution may have relatively large gaps between country scores, such that a significant improvement in index score is necessary to catch up leaders, or for those behind to catch other countries up. In general, it will thus be more meaningful to talk about countries' rankings, rather than their absolute index scores.

Reference Points

The question of approach in using relative versus absolute indices is closely connected to the issue of reference points. Indices with absolute scores are calculated as a proportion of fixed reference points. This has the advantage of permitting direct year on year comparability of scores (although, for the reasons cited above, the significance of a country's score depends upon its place in the index distribution), but it is unclear what these reference points should be for ICT achievements. With some indicators, maximum achievements are relatively straightforward: for example, 100% literacy rate, 100% Internet user rate. For other indicators, maximum achievements are less obvious. Mobile penetration may reach over 100% (e.g. for subscribers with more than one phone, or two SIM cards per phone). There are no established a priori ceiling limits for Internet host penetration.

The problem of an outlying 'star performer' is also illustrated in GIT's work, where the country with the maximum reference value forges ahead. "The U.S. increased [its electronics production] by $71B from 1996 to 1999. The U.S. position is so strong that even China's remarkable doubling of electronics production from $33B to $65B increases its score only from 12 to 19" (out of 100). This is partly apparent from Appendix 5, where the maximum reference values for ICT parameters are increasing at very rapid rates. The use of fixed reference values, as happened with UNDP's HDI could resolve this problem. However, with fast-changing ICT indicators, it is not evident what these fixed reference values should be (compared to life expectancy/literacy, where well-established upper ceiling values exist).
**Indicator Scores Methodology**

Scores are derived as an index relative to the maximum and minimum achieved in any indicator by countries:

\[
\text{Index score} = \frac{(\text{Value} - \text{Minimum})}{(\text{Maximum} - \text{Minimum})}
\]

Since the minimum value achieved is zero\(^1\) for most indicators, scores amount to a percentage of maximum values:

\[
\text{Index score:} = \frac{(\text{Value} - 0)}{(\text{Maximum} - 0)} = \frac{\text{Value}}{\text{Maximum}}
\]

Maximum reference values are given in Appendix 5 for connectivity. Indicators for which minimum values were not zero were telecoms traffic and telephone mainlines. However, these scores were calculated as a percentage of maximum values for consistency.

Appendix 1 presents the Index of ICT Diffusion calculated on the basis of the Connectivity and Access Indices for 2001, 2000 and 1999. On the basis of these rankings, countries are classified as *falling behind* (FB), 'keeping up' (KU) and 'getting ahead' (GA) corresponding to first, second and last thirds in rankings. To analyse trends in movements between 1995-2001, segmental analysis was carried out. Appendices 3 and 4 present the results for 2001, dividing countries into these categories on the basis of rankings for study of trends over time. This permits categorical analysis of results, by income level, region or culture. It also allows analysis of the scatter of observations, with frequency given in brackets after the title.

**Additive Model and Averaging**

There is no a priori logic for weighting indicators in their aggregation into the index. Simple averaging of indicators in an index implicitly assumes equal weighting of indicators and the possibility of offset of one indicator by another (i.e. mobiles are assumed to have equal importance to telephones, PCs and Internet hosts; connectivity is assumed equivalent to access and policy). GIT (2000) note that an "additive model implies that strength on any one of these dimensions could compensate for weakness on another". This is consistent with a sequential view of ICTs, rather than a synergistic one (where any weakness in the cluster reduces overall technological capabilities i.e. a multiplicative model as discussed previously).

Furthermore, use of simple averages across scores results in averaging effects. GIT (2000) recognises that "a given indicator combines several scores [so] typically no country will score 100 on the resulting indicators". In general, distributions are averaged into the centre of the scoring range. Averaging effects are noted by UNIDO (2002), which recognises the possibility of "offset... at least for some countries [where] use of two benchmarks together biases the results against them in that their average capabilities appear lower".

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\(^1\) Irving Fisher (1922)'s statistically desirable property of 'reversibility' (i.e. that the index calculated forwards and the index calculated backwards should be reciprocals of each other) is not fulfilled due to use of arithmetic averages in the indices. Use of 'zero' minimum values means that this 'reversible property' yields mathematically undefined answers (reciprocals of zero). However, this does not have any significant consequences for this index.
Time Period


Unit of analysis

Our units of analysis are nation states, countries or territories defined by national boundaries. Technological hubs, or "centres of excellence" with extensive hinterlands [Telegeography survey, quoted in UNDP's HDR (2001)] are aggregated into national level statistics and it is important to be aware of the significant averaging effect this has on our results. Adoption of nations and territories as our unit of analysis gives added pre-eminence to Singapore, as both a nation state and a "large city" (ITU, 2000), compared to e.g. a lower ranking for India, comprising Bangalore as a technological hub. Were New York or Bangalore to be separated out from their hinterlands, very different results would emerge. New York has more Internet hosts available to it than the whole of Sub-Saharan Africa which means that a city ranking, or ranking of nations by cities, would yield different results. Telegeography (2001)'s survey gives some indication of what a ranking by cities looks like.

Bridges.org observes that international digital divides have been assessed by comparisons of connectivity hardware between countries (PCs, hosts, servers, telephones), whereas domestic digital divides are assessed by measures of access by different groups (ethnicity, gender, age, income). The concept of disparities in access to ICTs is the same in both cases, but the level of analysis determines the choice of variables and method. The Mosaic Group (1996) measured the 'indigenisation' of IT capability, or "involvement by nationals… in installation, use, operation, maintenance, management and adaptation of technology… performed by indigenous personnel" [Mosaic 1996]. The Mosaic Group (1998)'s later theoretical framework assesses absorption of ICT technologies as independent, stand-alone technologies. National origin of technology is not considered.

Analysis of technology along national lines measures "national differences" in the adoption and absorption of IT. However, whether such differences are national or cultural may be indeterminate (boundaries of nation states and culture may coincide, but this is not always the case). Expatriate communities are often important in promoting technological adoption in their homelands (e.g. communication needs of overseas Vietnamese; the accumulated human capital of Indian software specialists in US).
National Size Effects

GIT (2000) note that Porter et al (1999)'s Innovation Index "is normalised (per capita measures), whereas [GIT's] is not (most of the statistical components reflect national totals). HTI address national technological competitiveness without particular concern for an economy's size". However, they do not explore the consequences of this for their results. In fact, this may introduce bias into results. UNIDO (2002) notes that "the use of a population deflator works against large countries, but remains a good way to adjust for country size". This may be particularly true for infrastructure, where a certain minimum threshold infrastructure in the network may be required, irrespective of the size of country. Further expansion of the network may benefit from economies of scale in larger countries, resulting in proportionately reduced levels of infrastructure per capita. Country size is intimately related to population dispersion and geographical dispersion of the network. It is unlikely that we will be able to correct for these effects; however, it is important to remain aware of their existence and the fact that averaging measures across per capita population may implicitly work against larger countries, lowering their relative rankings.

Data Omission Effects

The treatment of data omissions is central in determining the results of an index. In calculating the indices, final scores must be adjusted for the number of data observations and weighted, to eliminate the impact of data omissions. Failure to do so effectively 'dilutes' the final index score by the number of omissions. However, data omissions are more likely for poorer countries. This poses a problem for our results, the extent of which is unclear. For some indicators (e.g. telephone mainlines and mobiles, in the Connectivity Index), 201 countries have been covered to a reasonable extent. However, some indicators (e.g. local call costs, in the Access Index) have more limited data availability which varies from year to year. Rodriguez & Wilson (2000) note that their "results almost surely err on the side of optimism, as countries with poor or no available data are most likely to be the same countries that are being left behind by the information revolution". This caution also applies to our study. The omission of primarily poorer countries with low data availability means that absent or negligible observations are omitted. Our sample essentially comprises those countries with a degree of connectivity infrastructure in the first instance. This introduces bias from sample truncation into our findings, but it is difficult to establish the extent of this bias, or how to correct it.
4. DISCUSSION OF RESULTS

Results in this section are discussed by:

1. Income (UNDP codes of high-, middle- and low-income, others);

2. Regional groupings (UNDP codes of E. Europe and CIS, OECD, Arab states, E.Asia, S.Asia, Latin America & Caribbean, Sub-Saharan Africa, others);

3. Other regions, where geographical factors are important (e.g. 'island states').

Comparisons are also made between:

4. Connectivity and Access Indices and their relation in Appendix 3;

5. Policy and Connectivity Indices to study the impact of policy in enhancing ultimate connectivity in Appendix 4;

6. Evolution of indices over time; with particular attention paid to

7. Evolution of connectivity indicators over time, as representative of the digital divide.

as important comparisons within the ICT Development Indices. Telecoms policy is expected to impact mainly upon user numbers and cost variables in the Access Index, and less so on other variables of literacy and income, so this comparison was not analysed in detail. Positive correlations between sub-indices in Appendix 2 are illustrated by overweight positive diagonals. Random scatters of observations would yield equal weightings across boxes. However, frequency of observations (given by the figures in brackets) illustrates a positive correlation in weightings. The high correlations in our results may suggest that we are measuring consistent indicators of central 'technological development'. However, indices do not address the question of causation. These indicators may also represent proxy variables for key drivers underlying technological development (e.g. average income and/or level of development, levels of investment). Causation cannot be determined by correlations and it is proposed to investigate causation by regression work at a later date.

1. Income

UNDP codes were used to classify up to 171 countries into four categories of high-/middle-/low-income and 'others' for ICT Indices. To some extent, this analysis is partly dependent upon these classifications. Analysis of ICT rankings reveals that:

Table 3: Analysis of the Index of ICT Diffusion by Income
Average rankings conform to expectations. 'High' income countries consistently capture the top rankings, with an average ranking of 17-18.7. This average ranking is 55-60 places ahead of 'middle' income countries, which have a consistent average ranking between 73 and 81 over 1995-2001. 'Low' income countries show some decline in average ranking over this period, from 120 to 132 in 2001. 'Others' are too varied to yield meaningful conclusions. This pattern is apparent from the Connectivity Index for 200 countries using these categories:

**Table 4: Analysis of the Connectivity Index by Income**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>High: Best</td>
<td>U.S. 1</td>
<td>U.S. 1</td>
<td>U.S. 1</td>
<td>Finland 1</td>
<td>Finland 1</td>
</tr>
<tr>
<td>Worst Average</td>
<td>Brunei 82</td>
<td>Bahamas 62</td>
<td>Bahamas 64</td>
<td>Bahamas 62</td>
<td>Qatar 57</td>
</tr>
<tr>
<td></td>
<td>21.2</td>
<td>22.5</td>
<td>23.6</td>
<td>22.6</td>
<td>22.5</td>
</tr>
<tr>
<td>Middle: Best</td>
<td>Korea, Rep. 29</td>
<td>Korea, Rep. 29</td>
<td>Korea, Rep. 28</td>
<td>Korea, Rep. 30</td>
<td></td>
</tr>
<tr>
<td>Worst Average</td>
<td>Gabon 155</td>
<td>Djibouti 159</td>
<td>Eq. Guinea 183</td>
<td>Eq. Guinea 170</td>
<td></td>
</tr>
<tr>
<td></td>
<td>86.5</td>
<td>94.3</td>
<td>97.97</td>
<td>99.5</td>
<td>99.5</td>
</tr>
<tr>
<td>Low: Best</td>
<td>Georgia 89</td>
<td>Ukraine 100</td>
<td>Ukraine 100</td>
<td>Armenia 90</td>
<td></td>
</tr>
<tr>
<td>Worst Average</td>
<td>Niger 193</td>
<td>Congo DR 200</td>
<td>Guinea Bissau 201</td>
<td>Chad 201</td>
<td></td>
</tr>
<tr>
<td></td>
<td>158.6</td>
<td>163.7</td>
<td>165</td>
<td>163</td>
<td></td>
</tr>
<tr>
<td>Others: Best</td>
<td>Bermuda 11</td>
<td>Bermuda 5</td>
<td>Bermuda 5</td>
<td>Bermuda 7</td>
<td></td>
</tr>
<tr>
<td>Worst Average</td>
<td>Somalia 195</td>
<td>Afghanistan 199</td>
<td>Afghanistan 197</td>
<td>Afghanistan 200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>94.6</td>
<td>85.6</td>
<td>81</td>
<td>81.6</td>
<td>81.6</td>
</tr>
</tbody>
</table>

'High' income countries again capture the top connectivity rankings, with an average ranking of 21-23.6. This average ranking is 77 places ahead of 'middle' income countries, whose constant average ranking improves from 99.5 to 86.5 from 1995-2001. 'Low' income countries also show some improvement in average ranking over this period from 163 to 158.6. Again, 'others' is too varied a category to draw meaningful conclusions.
These results are however constrained by the broadness of these categories e.g. Djibouti, Gabon, Equatorial Guinea and Cote d'Ivoire are classified as middle-income countries, and Georgia, Ukraine and Armenia as low-income. The definitions of these categories constrains possible conclusions, so it is interesting to look at narrower regional classifications for more focused analysis.

2. Regional Groupings

UNDP codes were used to classify up to 171 countries into eight categories of E. Europe and CIS, OECD, Arab states, E.Asia, S.Asia, Latin America & Caribbean, Sub-Saharan Africa and 'others'. ICT diffusion rankings by these categories reveals:

Table 5: Analysis of the Index of ICT Diffusion by Regional Grouping

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1. OECD: Best Worst Average</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>U.S. 1</td>
<td>U.S. 1</td>
<td>Norway 1</td>
<td>Norway 1</td>
<td>Finland 1</td>
</tr>
<tr>
<td></td>
<td>Mexico 75</td>
<td>Mexico 73</td>
<td>Mexico 72</td>
<td>Mexico 71</td>
<td>Mexico 116</td>
</tr>
<tr>
<td></td>
<td>22.2</td>
<td>22.7</td>
<td>22</td>
<td>21.5</td>
<td>27</td>
</tr>
<tr>
<td>2. EE &amp; CIS: Best Worst Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Slovenia 27</td>
<td>Slovenia 28</td>
<td>Slovenia 30</td>
<td>Estonia 28</td>
<td>Slovenia 27</td>
</tr>
<tr>
<td></td>
<td>Uzbekistan 166</td>
<td>Albania 176</td>
<td>Azerbaijan 140</td>
<td>Azerbaijan 140</td>
<td>Uzbekistan 142</td>
</tr>
<tr>
<td></td>
<td>94.8</td>
<td>107.6</td>
<td>71</td>
<td>70</td>
<td>78</td>
</tr>
<tr>
<td>3. LAC: Best Worst Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bahamas 44</td>
<td>Costa Rica 46</td>
<td>Barbados 38</td>
<td>Uruguay 45</td>
<td>Guyana 41</td>
</tr>
<tr>
<td></td>
<td>Belize 128</td>
<td>Belize 131</td>
<td>Dominican Rep. 120</td>
<td>Dominican Rep. 125</td>
<td>Bolivia 146</td>
</tr>
<tr>
<td></td>
<td>71.7</td>
<td>77.6</td>
<td>79</td>
<td>79.5</td>
<td>78.6</td>
</tr>
<tr>
<td>4. E. Asia: Best Worst Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hong Kong 9</td>
<td>Hong Kong 8</td>
<td>Hong Kong 8</td>
<td>Hong Kong 11</td>
<td>Hong Kong 11</td>
</tr>
<tr>
<td></td>
<td>Cambodia 169</td>
<td>Cambodia 179</td>
<td>Myanmar 146</td>
<td>Lao 156</td>
<td>Mongolia 153</td>
</tr>
<tr>
<td></td>
<td>89.3</td>
<td>89.3</td>
<td>80</td>
<td>77</td>
<td>74.5</td>
</tr>
<tr>
<td>5. Arab: Best Worst Average</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>UAE 25</td>
<td>UAE 26</td>
<td>UAE 26</td>
<td>UAE 29</td>
<td>Kuwait 31</td>
</tr>
<tr>
<td></td>
<td>Yemen 140</td>
<td>Yemen 145</td>
<td>Sudan 127</td>
<td>Yemen 128</td>
<td>Egypt 154</td>
</tr>
<tr>
<td></td>
<td>88.8</td>
<td>91</td>
<td>80</td>
<td>82</td>
<td>89</td>
</tr>
<tr>
<td>6. S. Asia: Best Worst Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maldives 70</td>
<td>Maldives 70</td>
<td>Maldives 56</td>
<td>Maldives 77</td>
<td>Maldives 86</td>
</tr>
<tr>
<td></td>
<td>Bangladesh 148</td>
<td>Bangladesh 154</td>
<td>Bangladesh 133</td>
<td>Sri Lanka 134</td>
<td>Nepal 137</td>
</tr>
<tr>
<td></td>
<td>111.6</td>
<td>113.3</td>
<td>104</td>
<td>113</td>
<td>112</td>
</tr>
<tr>
<td>7.SSA: Best Worst Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mauritius 57</td>
<td>Mauritius 65</td>
<td>Mauritius 54</td>
<td>Mauritius 50</td>
<td>Mauritius 39</td>
</tr>
<tr>
<td></td>
<td>126.3</td>
<td>131.3</td>
<td>127</td>
<td>126.4</td>
<td>117</td>
</tr>
<tr>
<td>Others: Best Worst Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Israel 22</td>
<td>Israel 21</td>
<td>Israel 20</td>
<td>Israel 17</td>
<td>Israel 19</td>
</tr>
<tr>
<td></td>
<td>Sol. Islands 167</td>
<td>Sol. Islands 174</td>
<td>Vanuatu 148</td>
<td>Sol. Islands 141</td>
<td>St Vincent &amp; G 143</td>
</tr>
<tr>
<td></td>
<td>98.8</td>
<td>99.3</td>
<td>74.4</td>
<td>66</td>
<td>62.5</td>
</tr>
</tbody>
</table>

Average rankings conform to expectations. OECD countries consistently capture the top rankings, with average ranking improving from 27 to 22.2 from 1995-2001.  E.Europe and
CIS also improve in average ranking from 78 to 71 from 1995-1999, but decline afterwards to 94.8 in 2001. Latin American and Caribbean countries have a consistent ranking of 78.6-79 from 1995-1999, that improves to 71.7 in 2001. ‘E.Asian countries’ is a diverse category, encompassing Asian Tigers (e.g. best-performing Hong Kong at 11-8) and Cambodia, Lao PDR and Myanmar as countries tasked with ‘catching up’. E.Asia shows some decline in average ranking over this period from 74.5 to 88.7. ‘Arab’ countries are similarly diverse, encompassing countries ‘getting ahead’ (such as UAE and Kuwait) and countries ‘catching up’ (Yemen and Sudan), and have roughly constant ranking over this period, with average ranking varying between 80 and 90, and 88.8 in 2001. South Asia also shows an improvement from an average of 112 in 1995 to 104 in 1999, before slipping back to 111.6 in 2001. Sub-Saharan Africa's average ranking is consistently last but stable from 117 in 1995 to 126.3 in 2001, although its best-performers of Mauritius and South Africa generally rank between 50-65. ‘Others’ is a varied category. These trends are again apparent from the connectivity index rankings (see also analysis of regional groupings in connectivity in the Digital Divide Section):

Table 6: Analysis of the Connectivity Index by Regional Grouping

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. OECD: Best</td>
<td>U.S. 1</td>
<td>U.S. 1</td>
<td>Finland 1</td>
<td>Finland 1</td>
<td>Finland 1</td>
</tr>
<tr>
<td>Worst</td>
<td>Mexico 74</td>
<td>Mexico 88</td>
<td>Mexico 97</td>
<td>Mexico 97</td>
<td>Mexico 95</td>
</tr>
<tr>
<td>Average</td>
<td>22</td>
<td>25.4</td>
<td>26.6</td>
<td>27</td>
<td>29</td>
</tr>
<tr>
<td>2. EE/CIS: Best</td>
<td>Slovenia 25</td>
<td>Slovenia 28</td>
<td>Slovenia 31</td>
<td>Slovenia 36</td>
<td>Slovenia 40</td>
</tr>
<tr>
<td>Worst</td>
<td>Kyrgyz Rep.</td>
<td>Tajikistan</td>
<td>Tajikistan</td>
<td>Albania 152</td>
<td>Albania 158</td>
</tr>
<tr>
<td>Average</td>
<td>175</td>
<td>153</td>
<td>152</td>
<td>152</td>
<td>158</td>
</tr>
<tr>
<td>3. LAC: Best</td>
<td>Bahamas 49</td>
<td>Barbados 59</td>
<td>Barbados 57</td>
<td>Barbados 55</td>
<td>Barbados 51</td>
</tr>
<tr>
<td>Worst</td>
<td>Nicaragua 147</td>
<td>Nicaragua 147</td>
<td>Nicaragua 145</td>
<td>Nicaragua 144</td>
<td>Nicaragua 142</td>
</tr>
<tr>
<td>Average</td>
<td>86.4</td>
<td>93.9</td>
<td>95</td>
<td>97</td>
<td>92</td>
</tr>
<tr>
<td>4. Arab: Best</td>
<td>UAE 30</td>
<td>UAE 35</td>
<td>UAE 39</td>
<td>Qatar 51</td>
<td>Kuwait 44</td>
</tr>
<tr>
<td>Worst</td>
<td>Sudan 164</td>
<td>Sudan 169</td>
<td>Sudan 172</td>
<td>Sudan 178</td>
<td>Sudan 187</td>
</tr>
<tr>
<td>Average</td>
<td>103</td>
<td>107.4</td>
<td>109</td>
<td>108</td>
<td>108</td>
</tr>
<tr>
<td>5. E.Asia: Best</td>
<td>Hong Kong 12</td>
<td>Singapore 11</td>
<td>Hong Kong 12</td>
<td>Hong Kong 11</td>
<td>Hong Kong 13</td>
</tr>
<tr>
<td>Worst</td>
<td>Myanmar 188</td>
<td>Myanmar 192</td>
<td>Myanmar 184</td>
<td>Myanmar 186</td>
<td>Myanmar 180</td>
</tr>
<tr>
<td>Average</td>
<td>186</td>
<td>111.4</td>
<td>114</td>
<td>115</td>
<td>113</td>
</tr>
<tr>
<td>6. S. Asia: Best</td>
<td>Iran 97</td>
<td>Iran 104</td>
<td>Iran 101</td>
<td>Iran 99</td>
<td>Iran 101</td>
</tr>
<tr>
<td>Worst</td>
<td>Bangladesh 184</td>
<td>Bangladesh 190</td>
<td>Bangladesh 185</td>
<td>Bangladesh 189</td>
<td>Bangladesh 191</td>
</tr>
<tr>
<td>Average</td>
<td>148.3</td>
<td>153.6</td>
<td>150</td>
<td>150</td>
<td>151</td>
</tr>
<tr>
<td>7. SSA: Best</td>
<td>Mauritius 57</td>
<td>Mauritius 69</td>
<td>Mauritius 75</td>
<td>Mauritius 70</td>
<td>Mauritius 79</td>
</tr>
<tr>
<td>Worst</td>
<td>Somalia 195</td>
<td>Congo, DR 200</td>
<td>Guinea-Bissau 201</td>
<td>Chad 201</td>
<td>Chad 201</td>
</tr>
<tr>
<td>Average</td>
<td>156.7</td>
<td>162</td>
<td>166</td>
<td>166</td>
<td>167</td>
</tr>
<tr>
<td>8. Others: Best</td>
<td>Bermuda 11</td>
<td>Bermuda 5</td>
<td>Bermuda 5</td>
<td>Bermuda 7</td>
<td>Bermuda 5</td>
</tr>
<tr>
<td>Worst</td>
<td>Afghanistan 194</td>
<td>Afghanistan 199</td>
<td>Afghanistan 197</td>
<td>Afghanistan 200</td>
<td>Afghanistan 198</td>
</tr>
<tr>
<td>Average</td>
<td>90.4</td>
<td>83</td>
<td>78.7</td>
<td>79</td>
<td>77.8</td>
</tr>
</tbody>
</table>
For 1995-2001, average connectivity rankings conform to expectations and show remarkable consistency between periods. Furthermore, the same countries are consistently best or worst in their categories, which may reflect the long timescales needed to significantly improve levels of infrastructure. OECD countries consistently capture the top rankings, with average ranking improving from 29 to 22 from 1995-2001. E.Europe and CIS show a decline in average ranking from 92 to 99 from 1995-1999, and an improvement thereafter from 99-90 (overall unchanged), while Latin American and Caribbean countries show a steady improvement in average ranking from 100 to 86.4. In terms of connectivity, Arab countries outperform E.Asian countries (the reverse is true of wider ICT access and diffusion) with average Arab connectivity of 108-103 (compared to 113-106 for E.Asia). 'Arab' countries encompass countries 'getting ahead' (UAE, Qatar and Kuwait) and Sudan as their worst-performer, although Sudan improves steadily from 187-164. E.Asian countries include best-performing Hong Kong (between 11-13) and Myanmar as the worst performing (at 180-192). South Asia has a constant average of around 150, with consistent best-performer Iran and lower-performing Bangladesh. Sub-Saharan Africa's average ranking is consistently last but shows some improvement, from 167 to 156.7 with best performers of Mauritius and South Africa generally ranking between 57-85. Chad and Guinea-Bissau are the lowest performers at 201. 'Others' is again a varied category.

3. Other Regions

Regional classifications are reflected in the above UNDP's categories of E. Europe and CIS, OECD, Arab states, E.Asia, S.Asia, Latin America & Caribbean, Sub-Saharan Africa. However, for our purposes, further interesting results emerge from the Usage Index: telecom traffic, where the importance of 'island economies' is also apparent. These are small, relatively remote but highly connected islands such as Cayman Islands and Bermuda specialised in service industries. These 'island states' score highly in connectivity, beyond what might be expected from their geography, but in line with their specialisation in ICT-intensive service sectors. The negative impact of geography is also evident e.g. in respect of Nepal and Bhutan, where mountainous terrain prevents extensive network infrastructure. These countries score poorly in their regional classification of S.Asia and the satellite technology that can help overcome such terrain is not included in our Index.

4. Connectivity and Access Indices – Appendix 3

Connectivity and Access show high correlations of 0.786 (2001), 0.764 (2000), 0.776 (1999), 0.833 (1998) and 0.686 in 1995, as shown in Appendix 2. The strong correlation of the access index (comprising users, literacy, call costs and average income) with connectivity is embodied in the Index of ICT Diffusion, as the average of these two indices.

Appendix 3 illustrates this correlation, with countries lying mainly on the positive correlation diagonal and less so on the inverse diagonal. It is expected that good connectivity provides a basic foundation for and enhances good access (GDP income is an important underlying determinant of both access and connectivity infrastructure). Good access despite poor connectivity is counter-intuitive against expectations – only one country experiences good access (Costa Rica, due to good literacy rates and low call costs) with fifteen having
adequate access despite poor connectivity. Despite their relative rarity, these countries embodied by Costa Rica illustrate the possibilities for governments to enhance access beyond narrowly defined ICT connectivity with good literacy and low call costs. Transition economies generally enjoy strong literacy and education, improving access, but with reducing connectivity moving from Central and Eastern Europe towards Central Asian republics. This contrast is observed in our rankings in Appendix 3. The absence of good connectivity may make widespread access difficult to achieve, with a large 'vicious circle' (CU Con, CU Acc), populated largely by African and Asian subcontinent countries.

5. Policy and Connectivity Indices – Appendix 4

Policy and Connectivity index scores show a reasonable correlation in Appendix 2 of 0.516 (2001), 0.4297 (2000), 0.430 (1999), 0.426 (1998) and 0.403 (1995) although this is a retrospective comparison to make, since the policy variable relates to 2001-2002. This may also explain the reducing correlation the further back in time. The positive diagonal in Appendix 4 is again overweight in country observations, as expected from these correlations.

Segmental analysis of rankings presented in Appendix 4 illustrates strong regional groupings. The 'GA Con-GA Pol' box contains primarily OECD countries, engaged in a 'virtuous circle' with competitive telecoms sectors and good infrastructure. 'GA Con-KU Pol' contains Mediterranean and some former E. European countries. 'GA Con-CU Pol' contains Arab and island states with good infrastructure, but less liberalised telecoms policies. It is important to note that for offshore islands with small populations, a competitive telecoms sector may not be appropriate, contrary to the value judgments implicit in the scores.

The 'KU Con-GA Pol' box contains mostly Latin American and some Asian countries that may have implemented competitive policies, but have yet to witness the full benefits. The middle segment 'KU Con-KU Pol' contains the bulk of Central/Eastern European countries that have been cautious about or delayed telecom sector reforms. African countries dominate the 'catching up' (CU) Connectivity column.

However, countries in the 'CU Con-GA Pol' box offer the most potential. These are countries that may have recently implemented reforms (e.g. India, in the transition from monopoly to a more liberal market structure) and are waiting to reap the benefits, or countries that have had competitive market structures for some time, but lack the resources to invest heavily in infrastructure. However, a coherent competitive policy framework is in place, so these countries may be in a position to profit from their policies in the future. These regional groups in rankings highlight different types of economies under consideration and suggest that policy recommendations must be tailored to the different types of economy.
6. **Evolution over time**

Comparison of Appendices 3 and 4 reveals that rankings are relatively stable year on year. Comparisons of country movements in connectivity between years demonstrate relatively little movement between boxes, although some volatility within classifications may occur. This is consistent with high correlations observed between years:

**Table 7: Correlations within Indices between years**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>1</td>
<td>0.9918</td>
<td>0.9507</td>
<td>0.9476</td>
<td>0.9084</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td>1</td>
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<td>0.9590</td>
<td>0.9182</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>1</td>
<td>0.9849</td>
<td>0.9421</td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0.9553</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
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<td>1</td>
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<tbody>
<tr>
<td>2001</td>
<td>1</td>
<td>0.9617</td>
<td>0.9554</td>
<td>0.9483</td>
<td>0.9112</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td>1</td>
<td>0.9893</td>
<td>0.9798</td>
<td>0.9461</td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td></td>
<td>1</td>
<td>0.9893</td>
<td>0.9579</td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0.9789</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
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</tbody>
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</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>1</td>
<td>0.9867</td>
<td>0.8133</td>
<td>0.8297</td>
<td>0.7057</td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td>1</td>
<td>0.8211</td>
<td>0.8488</td>
<td>0.7167</td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td></td>
<td>1</td>
<td>0.9338</td>
<td>0.7725</td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0.8000</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
These correlations are consistent with UNIDO (2002)'s "considerable stability in Industrial Performance Scoreboard rankings... supporting the argument that capability building is a slow and incremental process". These could thus reflect the long-term nature of investments and prolonged timescales involved in expansion of telephone mainline networks. It also suggests that it may be difficult to break out of a 'vicious circle', but that benefits conferred by establishing a 'virtuous circle' with competitive policies may be long-term.

Appendices 3 and 4 provide a segmental analysis of rankings for the year 2001. Only 2001 is presented, but a review of movements from 1995-2001 yields further insights. China moved up the connectivity rankings from CU to KU in 1998, following liberalisation of its telecoms sector to full competition in long-distance and partial competition in its local loop. China also experienced considerable inward investment in this period. India and Pakistan retain CU Connectivity status. "The growth of telecommunications infrastructure in south Asia has not been demand-driven, unlike that of other countries where the infrastructure has been built and services operated by private investors... but almost entirely investment-driven, dependent on priority level... from limited public resources... [In India] connectivity remains low and unevenly distributed" (Indian "Economic and Political Weekly", 1999). However, different policy paths were pursued: "In Pakistan, the private sector dominates; in India the government [was] monopoly service provider [until the end of 1998/early 1999]; in Nepal, high cost of international communications was circumvented by a country-wide Intranet". These different policy paths do not appear to have had a strongly differentiated impact on respective connectivity. (Nb. India subsequently liberalised its telecom sector, accounting for its maximum policy score of 4 in 2001-2). Reforms and subsequent benefits in connectivity are also strongly differentiated in the FUSSR. In keeping with the World Bank and EBRD studies of economies in transition, the sharp contrast between CEE and the Central Asian region is observed in our rankings. For analysis of the evolution of connectivity indicators 1995-2000 which are of particular importance due to their relation to the 'digital divide', please see the next section.

4. THE DIGITAL DIVIDE

In their review of work carried out to assess the digital divide, Bridges.org observes that the digital divide between countries has typically been assessed by counts of hardware and connectivity (such as hosts, PCs, telephones, mobiles). We can analyse the distribution of our data on these variables to investigate their evolution over time, to see whether the "uneven diffusion" of technology (UNDP) is increasing or decreasing over time. Definitions of the 'digital divide' include:

1. absolute measures: the absolute gap between the most advanced country with highest hardware concentrations and the country with the lowest;

2. relative measures: measures of whether the distribution as a whole is growing more or less convergent with time;

3. categorical measures: whether the group of 'low-income' countries is converging with (relative to) the group of 'high-income' countries.

UNCTAD used the first three of these methods to analyse indicators of hardware connectivity and numbers of Internet users. These are basic indicators of the digital divide, which may be defined with more sophistication as access to and use of ICTs. It may not be the amount of hardware that is most important, but ultimately, the use that is made of this hardware and overall changes in the way the economy works. However, analysis of connectivity as the basic 'limiting factor' to ICT access and of actual numbers of Internet users evaluates bottlenecks and disparity in the first stages of access to ICTs.

1. Absolute Measures

In Appendix 5 presenting basic statistics describing the indicator data populations, absolute measures of the digital divide reveals steadily increasing maxima, medians and averages across all populations over the period 1995-2000. These populations indicate rapidly increasing maximum observations as the countries in the lead continue to forge ahead as 'star performers', while in most cases, minimum observations remain at, or close to, zero. (This is explained by these observations describing per capita penetrations. Absolute gains in telecommunications sectors cited by the ITU may thus be negated by gains in populations in some developing countries). It is often this 'absolute perceived gap' that is cited in popular observations about the digital divide - the gap between the most ICT-developed economies and the least ICT-developed appears to be wide, obvious and growing.

In terms of relative disparities, the evidence is rather more mixed. The distributions of these indicator populations are highly skewed, as indicated by significant standard deviations (as a percentage of mean) and discrepancies between the median and mean (both measures of central tendency, but the mean is more influenced by outliers). Appendix 5 indicates however that skewness in these distributions of averaged indicator penetrations per capita is decreasing marginally over time. The picture is one of digital leaders forging ahead in their absolute lead; however, newcomers may be catching up in terms of relatively less skewed distributions of hardware across countries, based on average hardware penetrations across countries as the basic unit of analysis.

Such average scores are only partially representative, however. These indicators are averages of total hardware equipment divided by total population for each country. They do not take account of the relative proportion of the world's population living in each country. The Gini measure of inequality weights the distribution of hardware equipment or Internet users by the relative proportion of the world's population for each country to produce a relative weighted measure of inequality.

2. Gini Coefficients

Preliminary analysis of Gini coefficients of inequality in levels of hardware equipment across nations reveals that levels of inequality in the distribution of hardware equipment are very high at 0.7-0.9, approximately twice the average level of income inequality observed for countries (between 0.3 - 0.4). Inequality in the distribution of technology across countries is undoubtedly high and substantial. Gini coefficients further reflect the relative age of the technologies, with greater inequality observed for more recently introduced technologies, such as Internet hosts (around 0.91) and Internet users (between 0.87 and 0.73). Internet
users are more evenly distributed than either PCs or Internet hosts, emphasising that access may differ from basic connectivity to the Internet. Telephones, as the oldest technology examined, consistently have the lowest Gini coefficients of all these technologies from 0.69 to 0.57 over the period 1995-2001. Mobiles are a notable exception to the age rule, with lower Gini coefficients than expected from the relative youth of this technology, that further reduce the fastest, from 0.82 to 0.66 over the period 1995-2001. This reflects the 'leapfrogging' noted by the ITU and UNDP. The 'digital divide', as measured by hardware equipment and Internet users, is undoubtedly wide and substantial.

Table 8: Gini Coefficients (figures in brackets give numbers of countries)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet hosts</td>
<td>0.915727</td>
<td>0.92052</td>
<td>0.91655</td>
<td>0.913665</td>
<td>0.912568</td>
<td>0.902182</td>
<td>0.910215</td>
</tr>
<tr>
<td></td>
<td>(193)</td>
<td>(199)</td>
<td>(200)</td>
<td>(200)</td>
<td>(200)</td>
<td>(198)</td>
<td>(199)</td>
</tr>
<tr>
<td>Internet users</td>
<td>0.732629</td>
<td>0.754422</td>
<td>0.809996</td>
<td>0.876371</td>
<td>0.85085</td>
<td>0.859376</td>
<td>0.870685</td>
</tr>
<tr>
<td></td>
<td>(160)</td>
<td>(183)</td>
<td>(195)</td>
<td>(187)</td>
<td>(181)</td>
<td>(171)</td>
<td>(136)</td>
</tr>
<tr>
<td>PCs</td>
<td>0.754002</td>
<td>0.754097</td>
<td>0.770972</td>
<td>0.76715</td>
<td>0.793778</td>
<td>0.791806</td>
<td>0.790808</td>
</tr>
<tr>
<td></td>
<td>(144)</td>
<td>(156)</td>
<td>(155)</td>
<td>(148)</td>
<td>(126)</td>
<td>(116)</td>
<td>(110)</td>
</tr>
<tr>
<td>Mobile subscribers</td>
<td>0.658388</td>
<td>0.703486</td>
<td>0.731545</td>
<td>0.775206</td>
<td>0.788291</td>
<td>0.816721</td>
<td>0.822235</td>
</tr>
<tr>
<td></td>
<td>(175)</td>
<td>(195)</td>
<td>(184)</td>
<td>(197)</td>
<td>(194)</td>
<td>(195)</td>
<td>(195)</td>
</tr>
<tr>
<td>Telephone mainlines</td>
<td>0.570299</td>
<td>0.589103</td>
<td>0.645535</td>
<td>0.66678</td>
<td>0.679151</td>
<td>0.69676</td>
<td>0.688234</td>
</tr>
<tr>
<td></td>
<td>(174)</td>
<td>(196)</td>
<td>(193)</td>
<td>(200)</td>
<td>(200)</td>
<td>(200)</td>
<td>(200)</td>
</tr>
</tbody>
</table>

The question of how the 'digital divide' is evolving, and whether it is growing or reducing over time is more complex. Gini analysis reveals relatively little overall change in the inequality of these distributions, with their evolution over time representing small, incremental reductions from their highly unequal levels. However, Gini coefficients as relative measures across the whole distribution do not identify exactly where contributions to reducing inequality come from. Given that Gini measures are weighted by population, countries with substantial populations, such as China and India, have greater influence in determining the Gini coefficient. It is doubtful that such contributions to reducing inequality derive from the tails of the distribution (as we saw from the absolute measures, 'best performers' are in fact increasing their lead, whilst some countries in the lower tail remain at, or close to, zero). Thus, these small reductions in inequality are coming from the centre of the distribution, but Gini coefficients only hint at a greater weighting for more populated countries – they do not tell us exactly which countries.

In the next section, we analyse relative movements in rankings to identify how countries and regions are faring in basic connectivity, to see which countries are contributing to reductions in inequality, increasing inequality, or merely preserving the status quo. Taken together, it is envisaged that these relative measures of the digital divide and the insights derived from benchmarking, provide a more detailed picture of developments in countries' ICT development.
3. Relative Movements in Country Rankings for Connectivity

Country rankings have two main characteristics: their current level and trend over time. To analyse relative movements in country rankings, connectivity rankings were divided into quartiles of 'Excellent' (1-50 places); 'Good' (51-100); 'Poor' (101-150) and 'Disadvantaged' (151-201). Trends in connectivity rankings over time were then assessed, to determine whether they were 'Improving', 'Same' or 'Declining'. In a sample of 201 countries, if 100 is taken as the median, the impact of trends in inequality on the status quo may be viewed as:

Table 9: Relative Movements in Country Rankings

<table>
<thead>
<tr>
<th>Level</th>
<th>Trend</th>
<th>Impact on Inequality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>Improving</td>
<td>Exacerbates inequality</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>Preserves the status quo</td>
</tr>
<tr>
<td></td>
<td>Declining</td>
<td>Reduces inequality</td>
</tr>
<tr>
<td>(50 countries)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>Improving</td>
<td>Exacerbates inequality</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>Preserves the status quo</td>
</tr>
<tr>
<td></td>
<td>Declining</td>
<td>Reduces inequality: trend towards median</td>
</tr>
<tr>
<td>(51 countries)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>Improving</td>
<td>Reduces inequality: trend towards median</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>Preserves the status quo</td>
</tr>
<tr>
<td></td>
<td>Declining</td>
<td>Exacerbates inequality</td>
</tr>
<tr>
<td>(52 countries)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disadvantaged</td>
<td>Improving</td>
<td>Reduces inequality: trend towards median</td>
</tr>
<tr>
<td></td>
<td>Same</td>
<td>Preserves the status quo</td>
</tr>
<tr>
<td></td>
<td>Declining</td>
<td>Exacerbates inequality</td>
</tr>
<tr>
<td>(49 countries)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(This is a judgemental exercise and not exact science: countries may be 'borderline' between categories, and move from one into another, accounting for the inexact numbers of countries in each category). The conclusions from such a review depend strongly on the regional classifications. UNDP classifications of regional and cultural groupings are used. Analysis of country rankings by categories reveals the following trends:

1. OECD countries

Consistent with the observations in Section 4 about regional rankings, OECD countries are consistently the best-performing countries in ICT development. OECD countries rank as having 'excellent' and 'good' connectivity and consistently capture first place (Finland, replaced by the U.S.) as maximum ranking, but with reducing minimum rankings from 95th to 74th place (Mexico). Consequently, the OECD average ranking reduces from 29 to 22 place from 1995-2001. Only three OECD countries show marginal declines in rankings (Finland, Australia and Canada) reflecting loss of first mover advantages and catch-up by other OECD countries. The standard deviation in rankings reduces correspondingly from 26 to 18, indicating a more closely-bunched grouping at the upper end of the distribution. OECD countries are effectively differentiating and separating out from the body of the distribution of country rankings, in an increasingly polarised distribution with OECD countries ahead.
ICT Development Indices

2. EE and CIS

Eastern European and the Commonwealth of Independent States demonstrate polarisation within their region. Maximum ranking is improving (Slovenia rockets up the rankings, from 40th place to 25th place from 1995 to 2001). However, minimum rankings slip from 158th place in 1995 (Albania) to 175th place in 2001 (the Kyrgyz Republic). This leaves overall average ranking unchanged, between 92-90 place, but leads to a steady increase in EE and CIS standard deviation in rankings, from 18 to 40. The EE and CIS region demonstrates increasing variation and polarisation, around approximately the same mean. (It is worth noting that variation would be further increased if Poland, Hungary and the Czech Republic were to be included in the CEE region, rather than under the OECD).

3. Latin America and Caribbean

Latin American and Caribbean countries show a steady improvement in average ranking from 100 to 86.4. Barbados and Bahamas have rankings around 51-49th place from 1995-2001. The minimum ranking (Nicaragua) declines from 142 to 147th place from 1995-2001. The average ranking improves slightly from 99 to 86, while standard deviation remains the same at 25. Overall, Latin America retains a stable distribution around a slowly improving average.

4. Arab Countries

'Arab' countries encompass best-performing Qatar, Kuwait and the United Arab Emirates (UAE) whose rankings improve from 44 to 30th place, and Sudan with the lowest ICT development, although Sudan improves steadily from 187-164th place from 1995-2001. This does not impact the average ranking and standard deviation, which remain unchanged at around 108 and 41 respectively. Overall, the contribution of Arab countries is therefore to maintain the status quo, with no major contributions to reducing inequality.

5. East Asia

E.Asian countries include best-performing Hong Kong and Singapore (between 11-13) and Myanmar as the worst performing, declining from 180 to 192 from 1995-2001. This leaves the overall average unchanged at 113-111 between 1995-2001, although there is some improvement to 106 in 2001, while the standard deviation hovers around 55. From the group regional perspective, there are no major developments. However, the most remarkable individual success story in East Asia is China, which rockets up the rankings in connectivity from 136th place in 1995 to 93rd in 2001. Given that China is host to one fifth of the world's population, China's steady rise in relative ranking is likely contribute substantially to the reduction in inequality showed by the Gini coefficients.
6. South Asia

South Asia demonstrates no real change overall and essentially preserves the status quo. The best maximum ranking varies between 101 and 97 (Iran) from 1995 to 2001, and the lowest between 191 and 194 (Bangladesh). This leaves overall average ranking preserved at 151-148, while standard deviation remains the same around 30. India, the most populous country with one sixth of the world's population, shows a slight improvement in ranking from 158 to 151 between 1995-2001. This may reinforce the reductions in Gini coefficient, representing a small reduction in inequality, but it seems likely that overall, the South Asian region does not contribute towards any major changes in overall inequality.

7. Sub-Saharan Africa

Africa demonstrates a wide variation in performance, between best-performing Mauritius, which improves from 79th place to 57th place from 1995-2001, and the bulk of Sub-Saharan African countries at the lower end of the distribution, including Chad, Guinea-Bissau, Congo and Somalia which occupy last place. The overall average ranking shows a small improvement in rankings, from 167 to 157, while standard deviation in rankings increases to reflect the growing variation from 28 to 32. Overall, there is thus an increasing deviation about a minimally improving average. However, African countries remain clustered towards the bottom of the distribution, so the overall contribution of Sub-Saharan Africa is to maintain the status quo, with no major contributions to reducing inequality.

6. CONCLUSIONS & WAY FORWARD

There are different aspects to 'multi-faceted' technology clusters, and ICTs may be defined and measured from several perspectives. Measurement across multiple aspects is necessary, to give rounded country profiles across the spectrum of ICT capabilities. Based on a review of previous work, we chose the aspects of connectivity, access, usage and policy as key components in the measurement of ICT development across countries. We measured technological profiles using a disaggregated index of ICT Diffusion, with component indices for connectivity, access and policy in the ICT Development Indices.

There is a trade-off of 'breadth versus depth' of indicators in such a cross-country analysis of as many countries as possible. It is difficult to achieve depth and complexity in indicators using standardised, cross-country indicators for broad comparability across many countries. The qualitative policy index contains an implicit value judgment in favour of competition in the telecoms sector, which does not allow for 'benign monopolies' or small economies where economies of scale may be appropriate. The policy index is, however, correlated with connectivity, which implies beneficial effects to telecoms liberalisation in terms of improved connectivity.

These different aspects are related, with strong positive correlations observed between connectivity and access and, to a lesser extent, competitive telecoms policy and connectivity.
This suggests that we are measuring central measures of 'technological development', although causation cannot be addressed with benchmarking indices – for example, we may be implicitly measuring proxy variables of income and/or development. Benchmarking provides useful information and meaningful analysis for policy purposes. Our cross-country analysis allows comparison between countries and monitoring of progress over time. It further allows straightforward identification based on evidence of 'success stories' for closer investigation for policy conclusions. Approached with thought, benchmarking is a useful input to policy analysis in allowing more informed and insightful study into policy and ultimately, in promoting better, faster and more effective ICT development.

Classification of countries as 'catching up', 'keeping up' and 'getting ahead' on the basis of rankings in the ICT Development Indices show consistent rankings over time, with high correlations and stable rankings (illustrative of these high correlations) between periods. This may reflect the long-term nature of infrastructure investments and policy reforms. Strong regional influences are apparent. As a broad generalisation, African and South Asian countries are classified as 'catching up', Latin American and transition economies as 'keeping up', and OECD countries and some South East Asian Tigers as 'getting ahead'. However, this masks considerable diversity with individual success stories such as Costa Rica and China, and the notable successes achieved in connectivity by Arab and 'island states', despite less competitive telecom policies. For island states, this may arise however, from their geographical situation and specialisation in service industries.

Trends in connectivity over time suggest stable country rankings from 1995 to 2001 and potential convergence in distributions of hardware, yielding the intriguing result of a diminishing digital divide, as defined narrowly by hardware measures. A review of the the digital divide and its evolution, as defined by hardware measures, has been carried out in terms of both absolute measures, Gini coefficients and an analysis of movements in country rankings. Taken together, this review suggests small, incremental reductions in inequality in the distributions of hardware and Internet users across countries, yielding the intriguing result of a diminishing digital divide. Our results show that more recent technologies such as the Internet are more unevenly distributed relative to older technologies, such as fixed line telephony. Our findings also demonstrate 'leapfrogging' in mobile telephony (with lower levels of inequality, which reduce the fastest), suggesting greater potential for mobiles as more equally distributed technologies in bridging the digital divide. Using a regional analysis of relative rankings, we reviewed levels of and trends in connectivity for different regions. Our results show that the 'tails' of the distributions are becoming more polarised, with OECD countries differentiating out from the body of the distribution of countries, and becoming increasingly more tightly bunched at the head of the distribution. Conversely, Sub-Saharan African remain grouped in the lower end of the distribution. These incremental reductions in Gini coefficients derive from the middle of the distribution, and China in particular, which accounts for a fifth of the world's population and shows a steady and substantial rise up the rankings.

It would be interesting to compare our indices and the changes in rankings therein with other indices (e.g. UNIDO's Infrastructure Index, McConnell International's and EIU's connectivity rankings). In future work, the challenging question of causation could be addressed to forge a link between the trends in outcomes observed and underlying policy by using more sophisticated statistical techniques. Regression work should include consideration of economies' sectoral composition, as reflected in the technological structure of exports and FDI as important determinants of and influences on countries' uptake and absorption of ICTs.
The following appendices are presented:

1. Appendix 1 – ICT Development Indices for 2001, 2000 and 1999 (by country and by ranking);

2. Appendix 2 – Correlations of component indices;

3. Appendix 3 – Comparison of Connectivity/Access Indices for 2001;

4. Appendix 4 – Comparison of Connectivity/Policy Indices for 2001;

5. Appendix 5 – Digital Divide work;


Appendix 1 presents ICT Development Indices and the Index of ICT Diffusion calculated as discussed above, in the section on Index Methodology for 2001, 2000 and 1999.


Appendices 3 and 4 compare Connectivity/Access Indices and Connectivity/Policy Indices for 2001 by categorising them as 'catching up' (CU), 'keeping up' (KU) and 'getting ahead' (GA). For connectivity, countries were divided into thirds, with the first third (1-67) classified as GA, second third (68-124) classified as KU and the last third (125-201) as CU. For access, countries were also divided into thirds, with the first third (1-53) classified as GA, second third (54-106) classified as KU and the last third (107-156) as CU. For policy, thirds closely corresponded to scores, so first third includes policy scores in excess of 0.5, the second third 0.5>/ x >0 and last third scores of zero. This allows the segmental classification and analysis of Connectivity with Access Index and Connectivity with Policy Index.

Appendix 5 presents exploratory data analysis for base data populations of Internet hosts, PCs, telephones and mobiles to present a preliminary analysis of the digital divide.

Appendix 6 provides a separate listing of the Connectivity Index, for 2001, 2000 and 1999.
### 7. Appendix 1: ICT Development Indices (2001)

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>2001 CONNECTIVITY</th>
<th>2001 ACCESS</th>
<th>2001-2 POLICY</th>
<th>2001 ICT DIFFUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>0.0005</td>
<td>..</td>
<td>0.1667</td>
<td>..</td>
</tr>
<tr>
<td>Albania</td>
<td>0.0500</td>
<td>0.0161</td>
<td>0.5000</td>
<td>0.0330666658</td>
</tr>
<tr>
<td>Algeria</td>
<td>0.0209</td>
<td>0.2248</td>
<td>0.0000</td>
<td>0.122837535</td>
</tr>
<tr>
<td>American Samoa</td>
<td>0.0321</td>
<td>..</td>
<td>0.0000</td>
<td>..</td>
</tr>
<tr>
<td>Andorra</td>
<td>0.2675</td>
<td>..</td>
<td>0.0000</td>
<td>..</td>
</tr>
<tr>
<td>Angola</td>
<td>0.0038</td>
<td>0.0110</td>
<td>0.6250</td>
<td>0.007400343</td>
</tr>
<tr>
<td>Antigua and Barbuda</td>
<td>0.3567</td>
<td>..</td>
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### Notes
- The table lists countries ranked by their index of ICT diffusion, with data presented for the year 2000. The index includes indicators for connectivity, access, policy, and diffusion in the ICT sector. The values range from 0 to 1, with higher values indicating more advanced ICT penetration.
### ICT Development Indices (2000)

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### 7. Appendix 2: Correlations of component Indices

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### 7. Appendix 3: Comparison of Connectivity/Access Indices

#### 2001 CONNECTIVITY VERSUS ACCESS PLOT OF RANKINGS

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<th><strong>GA CON – GA ACC</strong></th>
</tr>
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<td>(45)</td>
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<td>US, Iceland, Luxembourg, Sweden, Norway, Netherlands, Finland, Denmark, Switzerland, Australia, HK, Singapore, U.K., New Zealand, Ireland, Germany, Japan, Austria, Israel, Belgium, France, Canada, Italy, Slovenia, Korea, Portugal, Greece, UAE, Spain, Malta, Cyprus, Estonia, Greenland, Macao, Hungary, Bahrain, Slovak Rep., Croatia, Puerto Rico, Bahamas, Malaysia, Lithuania, Kuwait, Costa Rica.</td>
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<table>
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<th><strong>CU CON – KU ACC</strong></th>
<th><strong>KU CON – KU ACC</strong></th>
<th><strong>GA CON – KU ACC</strong></th>
</tr>
</thead>
<tbody>
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<td>(10)</td>
</tr>
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<td>Sri Lanka, Vietnam, Zimbabwe, Congo, Nicaragua, Eq. Guinea, Tajikistan, Pakistan, Gabon, Kenya, Cameroon, Lesotho, Nepal, Nigeria, Rwanda, Myanmar.</td>
<td>Trinidad &amp; Tobago, Argentina, Macedonia, Mexico, Venezuela, S. Africa, Romania, Russia, Saudi Arabia, Dominican Rep., Jordan, Colombia, Botswana, Ukraine, Fiji, China, Paraguay, Oman, Thailand, El Salvador, Moldova, Ecuador, Guyana, Tunisia, Maldives, Namibia, Guatemala, Boliv, Libya, Egypt, Swaziland.</td>
<td>Czech Republic, Qatar, Latvia, Bulgaria, Chile, Poland, Mauritius, Uruguay, Turkey, Jamaica.</td>
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</tbody>
</table>

<table>
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<th><strong>KU CON – CU ACC</strong></th>
<th><strong>GA CON – CU ACC</strong></th>
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<td>(3)</td>
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<td>Belize, Belarus, Georgia, Cape Verde, Iran, Azerbaijan, Bosnia, Morocco, Marshall Islands, Albania, Samoa, Turkmenistan, Syria, Mongolia, Senegal.</td>
<td>Seychelles, French Polynesia, Grenada.</td>
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## 7. Appendix 4: Comparison of Policy/Connectivity Indices

### 2001 CONNECTIVITY VERSUS POLICY PLOT OF RANKINGS

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</thead>
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<td>Argentina, Brazil, Yugoslavia, Mexico, Venezuela, Dominican Rep., Colombia, Georgia, China, Thailand, El Salvador, Peru, Philippines.</td>
<td>US, Iceland, Luxembourg, Sweden, Norway, Netherlands, Finland, Denmark, Switzerland, Australia, Hong Kong, Singapore, United Kingdom, New Zealand, Ireland, Germany, Japan, Austria, Belgium, France, Canada, Italy, Korea, Portugal, Czech Republic, Greece, Spain, Estonia, Malaysia, Chile, Poland.</td>
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<td>Trinidad and Tobago, Suriname, Macedonia, South Africa, Panama, Romania, Belarus, Russian Federation, Saudi Arabia, Jordan, Botswana, Ukraine, Cape Verde, Paraguay, Azerbaijan, Moldova, Bosnia and Herzegovina, Morocco, Ecuador, Tunisia, Albania, Namibia, Guatemala, Bolivia, Turkmenistan, Armenia, Egypt, Mongolia, Swaziland, Senegal.</td>
<td>Israel, Slovenia, UAE, Antigua and Barbuda, Malta, Cyprus, Hungary, Slovak Republic, Croatia, Latvia, Bulgaria, Lithuania, Kuwait, Uruguay, Turkey, Jamaica.</td>
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<table>
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<th>CU CON – CU POL</th>
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</thead>
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<tr>
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<td>(18)</td>
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<td>Belize, St. Lucia, Brunei, Faeroe Islands, St Vincent, Fiji, Barbados, Oman, Iran, New Caldeonia, Guyana, Virgin Islands, Marshall Islands, Maldives, Samoa, Lebanon, Libya, Syria, Cayman Islands, American Samoa.</td>
<td>Bermuda, Greenland, Aruba, Macau, Lichtenstein, Seychelles, Andorra, Bahrain, Qatar, Puerto Rico, Bahamas, Netherlands Antilles, French Polynesia, Mauritius, Dominica, Grenada, St. Kitts, Costa Rica.</td>
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7. Appendix 5: Digital Divide work

According to Bridges.org, the international digital divide has typically been assessed by counts of hardware and connectivity (hosts, PCs, telephones, mobiles). We can analyse the distribution of these variables to investigate their evolution over time, to see whether "uneven diffusion" (UNDP) is in fact increasing or decreasing over time:

Table A – Summary Statistics

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### ICT Development Indices

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Table B – Evolution over time of statistics on average per capita variable distributions

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Table C – Summary Statistics of Connectivity Index

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Data Appendix

Variable Sources and Definitions:

1. **Internet Hosts**: Internet hosts are the number of computers with active Internet Protocol addresses connected to the Internet, per 10,000 people. Source: ITU.

2. **Personal Computers**: Personal computers are the estimated number of computers designed to be used by a single individual, per 1,000 people. Source: ITU.

3. **Telephone Mainlines**: Telephone mainlines are the estimated number of telephone mainlines, per 1,000 people. Source: ITU.

4. **Mobile Phones**: Mobile phones are the number of mobile phone subscribers, per 1,000 people. Source: ITU and UNSD population estimates.

5. **Internet Users**: Number of Internet users per 1,000 people. Source: ITU.

6. **Literacy**: Literacy rate calculated as the inverse of the illiteracy rate. Source: World Bank and UNCTAD.


8. **Cost of a Local Call**: Estimated cost of a 3 minute local call in US dollars. Source: ITU.

9. **Telecom Traffic Outgoing**: Estimated number of minutes outgoing traffic. Source: ITU.

10. **Telecom Traffic Incoming**: Estimated number of minutes incoming traffic. Source: ITU.

11. **Internet Exchange**: Presence of an Internet Exchange (IX) point, defined by Telegeography as "services created to facilitate on-site interconnections between independent or third-party Internet networks ". Source: Telegeography.

12. **Competition in Local Loop**: full/partial competition, duopoly, monopoly. Source: ITU.

13. **Competition in Long-distance**: full/partial competition, duopoly, or monopoly. Source: ITU.

14. **Competition in ISP market**: whether the ISP market may be described by full/partial competition, duopoly, or monopoly. Source: ITU.
8. BIBLIOGRAPHY


Lall (2001) reviews the distinctions and evolution of these innovation indices in his article "Competitiveness Indices and Developing Countries: An Economic Evaluation of the GCR", World Development 2001.


Georgia Institute of Technology High Tech Indicators and associated articles, available from (http://www.gatech.edu/)


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