UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

THE DIGITAL DIVIDE REPORT:

ICT DIFFUSION INDEX 2005

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PREFACE

Regardless of how we measure it, there is an immense information and communication technology (ICT) gap, a “digital divide”, between developed and developing countries. A person in a high-income country is over 22 times more likely to be an Internet user than someone in a low-income country. Secure Internet servers, a rough indicator of electronic commerce, are over 100 times more common in high-income than low-income countries. In high-income countries, mobile phones are 29 times more prevalent and mainline penetration is 21 times that of low-income countries. Relative to income, the cost of Internet access in a low-income country is 150 times the cost of a comparable service in a high-income country. There are similar divides within individual countries. ICT is often non-existent in poor and rural areas of developing countries.

The Internet is a unique form of ICT. It is efficient and general purpose, designed to carry any type of data and support any application. This efficiency and generality is achieved by a design, which keeps the network simple while allowing the users at the “edge” of the network to invent applications and provide content and services. In addition to innovation, the bulk of the investment takes place at the edge of the network.

Since its inception, we have hypothesized that, while not a cure-all, the Internet could raise the quality of life in the developing world. This has led us to conduct hundreds of national "e-readiness" studies, train technicians and policymakers, run pilot studies, develop and deploy applications, and convene hundreds of conferences, including the recent World Summit on the Information Society (WSIS). We have demonstrated viable applications in health and veterinary care, education, agricultural markets, advice, and transportation, entertainment and games, news, personal communication (text, voice, video) and e-government. Yet, after all of this activity, Internet connectivity is nearly non-existent in rural areas of developing countries and, when it is available in urban areas; it is decidedly inferior to the service in developed countries.

We have hoped that national ICT policies of private sector participation, competition and effective regulation (PCR) would close the digital divide. While they have helped to reduce it slightly in certain areas, the digital divide persists, particularly among the least developed countries. Anticipated returns are insufficient to attract capital to build networks in low-income countries. While valid, PCR has limits. Pure competition does not exist in telecommunication. Duopoly is common and services are often either not available or have only a single provider in many areas within both developed and developing countries.

If we are to close the digital divide, we must go beyond PCR policy by coupling it with proactive government planning, investment and procurement. After updating UNCTAD's Information and Communication Technology Diffusion Index for 2005 and documenting the digital divide, this report presents case studies in which proactive governments have gone beyond PCR to create successful ICT policy. This leads us to discussion of proposals to construct public Internet backbones which would provide neutral connection points for competing service providers — the type of eclectic strategy seen in our successful case studies. There are roughly one billion people in about 800,000 villages in developing countries without any kind of connection. Providing each village with a high speed Internet connection would be a daunting task, a "Grand Challenge", but we believe that this goal could be achieved.

In line with the commitments taken in the Tunis Agenda for the Information Society, UNCTAD will continue to work with other stakeholders, including ITU, to measure progress in bridging the digital divide.

Dr. Supachai Panitchpakdi
Secretary-General of UNCTAD

ACKNOWLEDGEMENTS

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We wish to thank the International Telecommunication Union for providing us with the telecommunication data needed to estimate the indices.

CONTENTS

ABBREVIATIONS AND ACRONYMS

ADSL	asymmetric digital subscriber line
BTA	Botswana Telecommunication Authority
BTC	Botswana Telecommunications Corporation
CEE & CIS	Central and Eastern Europe and the CIS
CIS	Commonwealth of Independent States
CSTD	Commission on Science and Technology for Development
EASSy	Eastern African Submarine Cable System
ERI	E-government readiness index (UN)
ERNET	Education and Research Network (India)
GDP	gross domestic product
GIT	Georgia Institute of Technology
HDI	human development index (UNDP)
ICT	information and communication technology
ICTDI	information and communication technology diffusion index
IDA	Infocomm Development Authority (Singapore)
IP	Internet Protocol
ISP	Internet services provider
IT	information technology
ITU	International Telecommunication Union
IXs	Internet exchange points
LAC	Latin America and the Caribbean
Mbps	megabytes per second
MII	Ministry of Information Industry (China)
MPT	Ministry of Posts and Telecommunications (China)
MSSRF	M.S. Swaminathan Research Foundation
NTP	National Telecom Policy (India)
OECD	Organisation for Economic Co-operation and Development
PCR	privatization, competition and independent regulation
PCO	public call offices
POP	point of presence
PPP	purchasing power parity
SSA	Sub-Saharan Africa
SUBTEL	Sub-secretary of Telecommunication (Chile)
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
VoIP	voice over Internet protocol
WSIS	World Summit on the Information Society
WTO	World Trade Organization
3G	third generation (mobile)

OVERVIEW

The first section presents our information and communication technology diffusion index (ICTDI) for 2004. As expected, we see a strong correlation between a country's ICTDI and its income and level of human development as measured by the UNDP's Human Development Index (HDI). The top ranks are dominated by industrial countries from North America, Western Europe and the Asian Tigers, while many of the lower ranking countries are from Africa. Since the ICTDI is measuring the outcome of a complex socio-technical system, the ranks are relatively stable over time; however, we do observe more volatility in low-ranking countries than in high-ranking countries.

In section two we consider the digital divide. We see that regardless of the measure used, the digital divide exists and national rankings are quite consistent. The digital divide is also wide.[1] For example, in spite of the fact that there are many Internet cafés and other telecentres in low-income countries, a person in a high-income country is over 22 times more likely to be an Internet user than one in a low-income country; this is significant as 37 per cent of the world population lives in a low-income country. This is not surprising as the cost of slow, unreliable Internet service in a low-income country is greater than the cost of fast, reliable service in a high-income country. Internet affordability is over 150 times greater in a high-income than a low-income country. The only somewhat bright spot in this picture is that analysis of Lorenz curves and Gini coefficients indicates that ICT diffusion is slowly becoming more equal.

Section three presents case studies from China, Chile, Botswana, Singapore, India and the United States. These nations were selected because they have combined ICT liberalization — privatization, competition and independent regulation — with responsible government planning, investment and procurement. We briefly outline the broad political and economic context in which telecommunication policy is formed in each nation, describe that policy and examine some of the results.

The latter part of the twentieth century witnessed a global trend away from protected, controlled economies toward open, market economies. Telecommunication was included in this movement, and the dominant telecommunication policy has favoured privatization, competition and independent regulation (PCR). Section four reviews this history and its success, but also examines some of its limitations. The persistence of the digital divide suggests that while historically beneficial, PCR may have reached a point of diminishing returns in many nations and that we now need to look beyond PCR.

[1] See also UNCTAD's *Information Economy Report* (2005).

Application-neutral Internet technology is able to deliver all telecommunication services, and during more than a decade of application development and pilot studies, we have demonstrated its efficacy in improving quality of life in developing nations through applications in healthcare, education, entertainment, government services, business, personal and political communications, agriculture and veterinary medicine, etc. As such, we conclude the section by considering proposals to construct public Internet backbones which would provide neutral connection points for competing service providers — the type of eclectic strategy we have seen in our case studies.

The report concludes with appendices on the methodology used in computing the ICTDI and annexes showing the national ICTDI values for 2004 and the ranks for 1997-2004.

1. BENCHMARKING ICT DEVELOPMENT

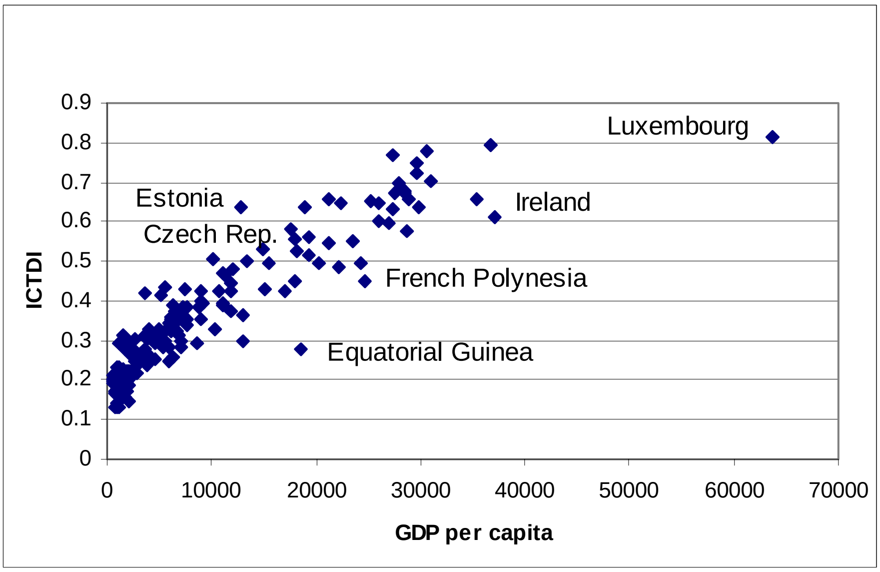
This section discusses our ICT diffusion index (ICTDI), which is tabulated in section 6, Annex tables. Annex table 1 shows the 2004 ICTDI values for 180 countries, sorted by rank; Annex table 2 is an alphabetized table showing the ICTDI ranking from 1997 to 2004. Broadly speaking, the index is a function of connectivity in a nation and the people's ability to access and utilize it. The index and our methodology are defined in the appendices.

Section 1.1 analyses the overall 2004 rankings; section 1.2 analyses the data by income and regional groupings since 1997; section 1.3 gives the major "gainers" and "decliners" during the 1997-2004 period.

1.1. 2004 ICT diffusion index: main results

The strong relationship between the level of ICT development within a country and its level of income is clear. With the exceptions of Estonia and the Czech Republic, the top 30 ICTDI countries fall within the UNDP high income category. All 30 are rated as having a high level of human development using the UNDP Human Development Index (HDI) which is a function of income, education and life expectancy[2] (UNDP, 2004).

Figure 1. ICTDI vs. GDP per capita, 2004

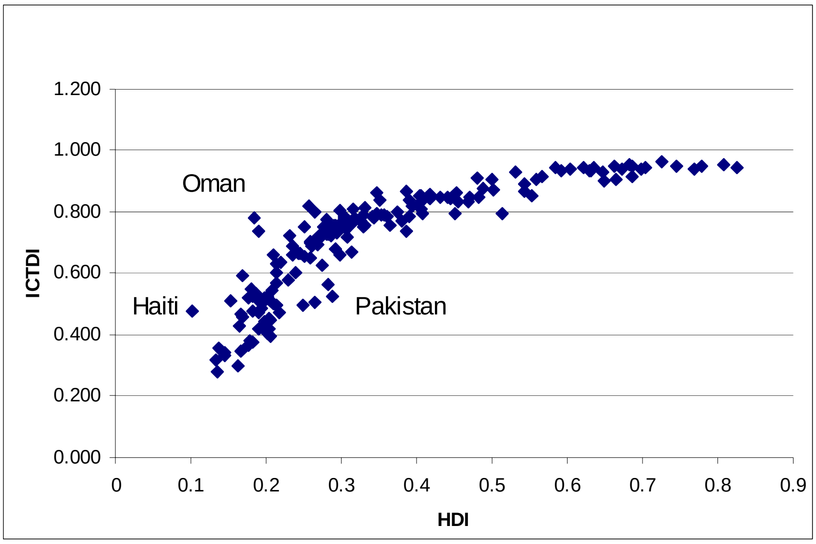


Source: World Bank, *World Development Indicator Online 2005 for GDP* and authors' calculations.

[2] High income: GNI per capita in 2003: $9,386 or above; middle: $766-9,385; and low: $765 or less (UNDP, 2004).
High human development: HDI .800 or above, middle: 0.500–0.799), and low: less than 0.500 (UNDP, 2005).

Figure 1 shows the relationship between ICTDI and GDP per capita.[3] The relationship is strong, but appears to be somewhat different at the lower end of the scale. There is a cluster of 42 low-income countries with GPD less than or equal $2,373 and ICTDI less than or equal .231. For those countries, the relationship between ICTDI and income is relatively weak.

Figure 2. ICTDI vs. HDI, 2003



Source: UNDP (2005) for HDI and authors' calculations.

Figure 2 also shifts at the low end. The relationship is strongest for the 91 countries with HDI below .300, indicating that health and education are strongly correlated with ICT for low-income countries.

We also see outliers in Figures 1 and 2, and explaining them can be instructive. For example, in Equatorial Guinea new oil revenue has pushed GDP (7 per cent growth from 1995-2004) up much faster than either the HDI or ICTDI. French Polynesia has benefited from tourism, and the emphasis of the Estonian government on developing and using ICT is reflected in the fact that they are an outlier in the other direction. The income level in Luxembourg makes it a somewhat unique case as does the low-level of human development in Haiti. The political situation in and around Pakistan has affected ICT development and Oman's position might be attributable to pro-ICT government policy coupled with reliance upon expatriate workers.

The upper ranks of the ICTDI are dominated by OECD countries: the top ten countries in the ICTDI ranking are all OECD countries, as are all but three of the top 25.[4] Western Europe and North America dominate the top 25 spots. Twentieth-ranked Estonia leads the ex-Soviet-bloc countries and Slovenia and the Czech Republic are 29th and 30th. Israel and the Asian Tigers round out the top 30.

[3] The GDP per capita is a component of the ICTDI. Hence the positive correlation between the GDP per capita and the index is partly due to its construction. However, additional calculations showed that that the correlation between ICTDI and GDP per capita remains highly significant even when the GDP per capita is excluded from the index.
[4] Bermuda is an overseas territory of the United Kingdom.

Other European countries, the Caribbean tourist destinations and relatively wealthy Middle Eastern nations tend to lead the next group. At 56th, Chile is the highest-ranked nation in South America, followed by her southern cone neighbours Argentina and Uruguay; Costa Rica leads in Central America. The Andean and other South and Central American countries are behind them. Brazil, ranked 76th, and China, ranked 90th, are important because of their size and growth.

Thirty four of the lowest ranking 45 nations are in sub-Saharan Africa. India and its neighbours Nepal, Bhutan and Pakistan also fall into this group. The other low ranking countries tend to be scattered around the world — for example, Haiti, Cambodia, Lao People's Democratic Republic, Solomon Islands, Papua New Guinea and Yemen.

1.2. Income analysis and regional performance: overall trends 1997–2004

This section provides an overall analysis from 1997 to 2004 by income and regional groupings.

Table 1. ICT diffusion index by income[5]

	1997		2001		2004	
High income:						
Best	Norway	1	United States	1	Luxembourg	1
Worst	Bahrain	44	Kuwait	55	Brunei Darussalam	59
Average		21		22		23
Middle income:						
Best	Estonia	35	Czech Republic	32	Estonia	20
Worst	Djibouti	156	Djibouti	141	Djibouti	141
Average		88		86		85
Low income:						
Best	Uzbekistan	71	Uzbekistan	92	Moldova	92
Worst	Central African Rep.	180	Democratic Rep. of Congo	180	Niger	180
Average		145		147		148

Source: UNDP income classification, and authors' calculations.

Table 1 illustrates the positive relationship between the level of income and the level of ICT diffusion: in 2004, the average ranking was 23 for high-income countries, 85 for middle-income countries and 148 for low-income countries. From 1997 to 2004, the average ranking of high-income countries remains rather stable (between 21 and 23), it is improving for middle-income countries (from 88 to 85), but declining for low-income countries (from 145 to 148). Thus, despite a rather stable overall trend, Table 1 reveals the slow but increasing polarization of low-income countries.

[5] UNDP income classification depends on the GNI per capita in 2002; "high income": $9,076 or more; "middle income": between $736 and 9,075; "low income": $735 or less.

Table 2. ICT diffusion index by regional groupings

	1997		2001		2004	
Western Europe						
Best	Norway	1	Luxembourg	3	Luxembourg	1
Worst	Malta	38	Greece	34	Greece	40
Average		19		18		19
OECD						
Best	Norway	1	United States	1	Luxembourg	1
Worst	Mexico	101	Mexico	72	Mexico	77
Average		25		22		23
European Union						
Best	Finland	3	Luxembourg	3	Luxembourg	1
Worst	Poland	57	Lithuania	54	Poland	49
Average		28		26		25
CEE & CIS						
Best	Albania	105	Albania	102	Albania	95
Worst	Azerbaijan	117	Armenia	109	Azerbaijan	100
Average		110		105		98
LAC						
Best	Saint Kitts and Nevis	42	Saint Kitts and Nevis	52	Saint Lucia	50
Worst	Guatemala	134	Haiti	139	Haiti	138
Average		92		88		88
East Asia						
Best	Hong Kong (China)	10	Hong Kong (China)	11	Hong Kong (China)	12
Worst	Solomon Islands	173	Solomon Islands	175	Solomon Islands	175
Average		95		95		98
Arab states						
Best	United Arab Emirates	37	United Arab Emirates	38	Qatar	41
Worst	Somalia	157	Yemen	164	Yemen	163
Average		104		107		105
North Africa						
Best	Libya	94	Libya	108	Tunisia	102
Worst	Morocco	154	Egypt	137	Egypt	134
Average		126		127		123
South Asia						
Best	Maldives	80	Maldives	73	Maldives	72
Worst	Bangladesh	164	Bangladesh	171	Bangladesh	171
Average		132		139		139
SSA						
Best	Seychelles	58	Seychelles	46	Seychelles	51
Worst	Central African Rep.	180	Democratic Rep. of Congo	180	Niger	180
Average		146		145		145

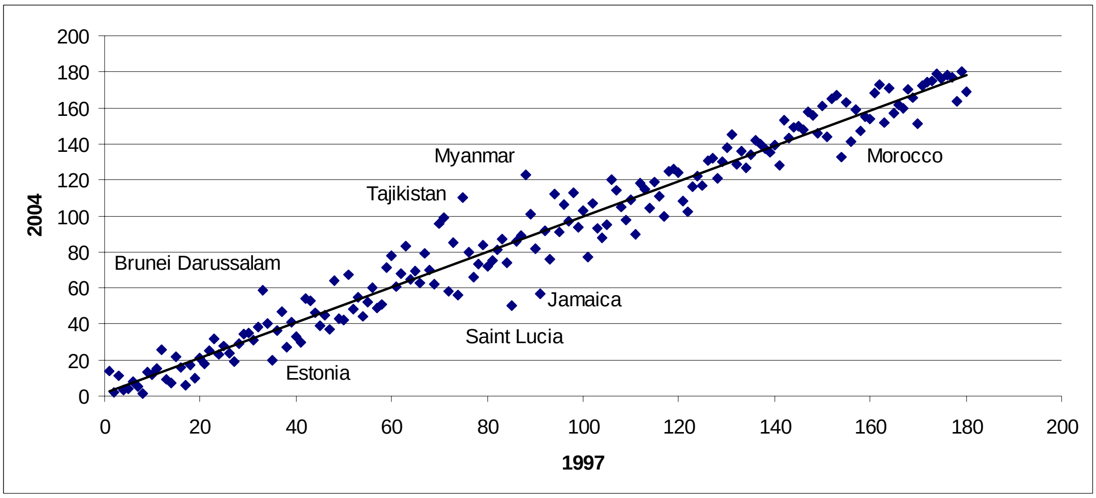
Source: UNDP regional classification and authors' calculations.

Table 2 shows the overall ranking of ten regions and economic groupings. Note that their average ranking remains in the same order in each year. Western Europe, The European Union and the OECD countries are consistently at the top of the rankings. The CEE and CIS average ranking has improved steadily from 110 in 1997 to 98 in 2004. The Latin America and Caribbean average has improved slightly from 92 to 88 in the same period. East Asia is the most diverse region in terms of income levels and ICT development. It includes economies such as Hong Kong (China), ranked 12th, Singapore, ranked 16th and the Republic of Korea, ranked 19th, as well as Cambodia, ranked 140th and the Lao People's Democratic Republic, ranked 145th. The differences between the developed and emerging countries in this region are much greater than the slight drop in average ranking for the region. North Africa has improved somewhat despite the fact that Libya's ranking fell during this period. The average ranking for the Arab states is nearly unchanged while South Asia has declined from an average rank of 132 to 139. Sub-Saharan Africa has remained nearly constant in ranking at the bottom of all regions.

1.3. Gainers and decliners, 1997-2004

As one would expect with slow-moving socio-technical systems, the rankings are fairly stable. Figure 3 compares national ICTDI rankings in 1997 with those of 2004. There is a strong relationship between them and several outliers which have moved up or down relatively rapidly are indicated.

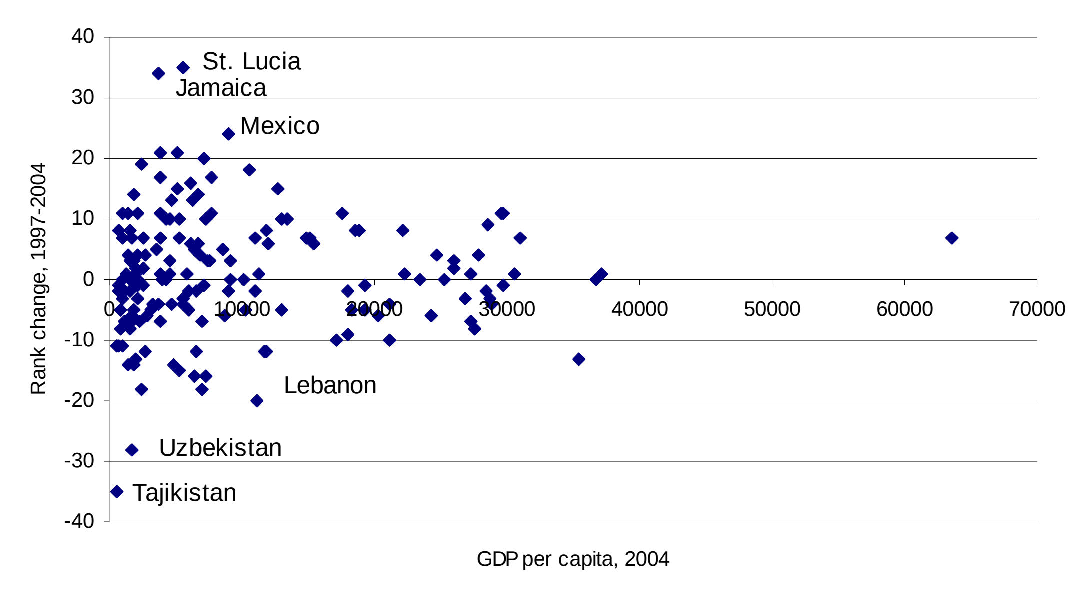
Figure 3. ICTDI rank: 1997 vs. 2004



Source: Authors' calculations.

As shown in Figure 4, the rankings of relatively low-income countries are more volatile.

Figure 4. Rank change between 1997 and 2004 vs. GDP per capita



Source: World Bank, *World Development Indicator Online 2005* for GDP and authors' calculations.

We see a discontinuity around $14,000 GDP per capita, and indeed the standard deviation of rank change among countries below that point is 7.27 compared to 3.62 for nations above it.[6] Further analysis would be necessary to explain this phenomenon, but it might be due to lower measurement reliability or to the fact that among nations with very little, a small change results in large rank shifts.

Table 3 shows the top ten gainers and decliners for 1997–2004. Extreme changes such as these can be causes for alarm or examples to emulate.[7] Small declines may be due to "neighbourhood effects," where neighbouring countries in the ranking managed to improve faster than others, even if there was no real decline in ICT development for the latter (UNCTAD, 2004).

Table 3. Major gainers and decliners in ICT diffusion ranking, 1997–2004

Country name	1997	2004	Change	Country name	1997	2004	Change
Saint Lucia	85	50	+ 35	Tajikistan	75	110	- 35
Jamaica	91	57	+ 34	Myanmar	88	123	- 35
Mexico	101	77	+ 24	Uzbekistan	71	99	- 28
China	111	90	+ 21	Marshall Islands	70	96	- 26
Morocco	154	133	+ 21	Brunei Darussalam	33	59	- 26
Tunisia	122	102	+ 20	Lebanon	63	83	- 20
Papua New Guinea	170	151	+ 19	Libya	94	112	- 18
Chile	74	56	+ 18	Kazakhstan	60	78	- 18
Azerbaijan	117	100	+ 17	Grenada	51	67	- 16
Brazil	93	76	+ 17	Belarus	48	64	- 16

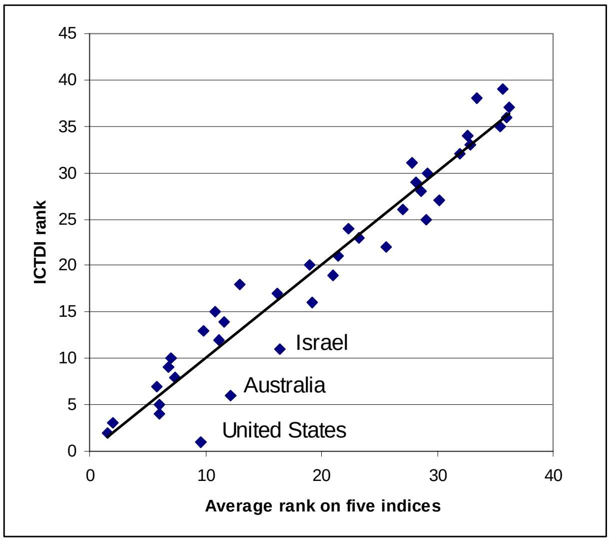
Source: authors' calculations.

[6] The difference between these two figures is highly significant (f=4.03, n1=128, n2=41).
[7] To put these changes in context, the overall average rank change between 1997 and 2004 was 7.87 places.

2. THE DIGITAL DIVIDE

Regardless of how one measures it, the digital divide exists and is wide. We have used the ICTDI in documenting the digital divide, but it correlates highly with other indices. Figure 5 plots ICTDI against the average values of five ICT indices compiled by Minges (2005).[8] We can gather from this figure that there is a high correlation (the correlation coefficient is .97) in spite of a few outlying countries.[9]

Figure 5. The ICTDI vs. the average of five other ICT indices



Source: Minges (2005) and authors' calculations.

2.1. ICT diffusion by income group

Tables 4, 5 and 6 (World Bank, 2006) demonstrate the magnitude of the digital divide. Table 4 shows the World Bank income categories, and as we see the majority of the population lives in low- or lower-middle-income countries.

Table 4. World Bank income group categories, 2004

Income group	GNI per capita (US$)	Number of countries	Population (millions)	Population (%)
High	above 10 066	55	1 001	16
Upper middle	3 256 - 10 065	40	576	9
Lower middle	825 - 3 255	54	2 430	38
Low	below 825	59	2 338	37
World		208	6 345	100

Source: World Bank (2006).

[8] Minges compiled data on 40 countries, but we show only 39 since the ICTDI has not been computed for Taiwan Province of China.

[9] Some of the variance is due to differences in the time each index was compiled. For example, the discrepancy in the rankings for the United States may be due to recent relative declines on some ICT indicators.

Table 5 shows the relationship between income groups and several commonly used ICT indicators.

Table 5. ICT indicators by income groups

Income groups	Internet users per 1,000 people 2003	Mobile phones per 1,000 people 2003	Telephone mainlines per 1,000 people 2002
High	366	698	575
Upper middle	209	355	211
Lower middle	62	195	144
Low	16	24	27
World	150	223	176

Source: World Bank (2006).

A person in a high-income country is over 22 times more likely to be an Internet user than someone in a low-income country. In spite of their rapid growth in developing countries, mobile phones are 29 times more prevalent in high-income countries than low and high-income countries as mainline penetration is over 21 times that of low-income countries. It is somewhat encouraging that the divide between high- and lower-middle-income countries is notably smaller; however, it is still very large as 2.3 billion people live in low-income countries.

2.2. ICT affordability by income group

There are many reasons for the digital divide, but most of them correlate with the primary cause, poverty. As we see in Table 6, the Internet is impossibly expensive for with people with low-incomes.

Table 6. Indicators of ICT affordability by income group

Income group	Monthly price for 20 hours of Internet use US$ 2003	Internet price as % of monthly GNI per capita 2003	Average cost of local call US$ per 3 minutes 2002
High	23.51	1.7	0.07
Upper middle	30.27	13.3	0.09
Lower middle	31.82	32.2	0.03
Low	56.31	258.3	0.07
World	36.91	88.7	0.06

Source: World Bank (2006)

Twenty hours of Internet service costs roughly twice that of a high-income country and is over 2.5 times the average monthly income in a low-income country. In a high-income country, Internet affordability relative to income is over 150 times better than a low income nation. Even in lower-middle-income nations, the cost of 20 hours of inferior Internet service represents nearly one third of the average monthly income. It is only in high-income countries that the cost of Internet service is low enough as to be broadly affordable for most households and small businesses; even in these nations, we observe internal digital divides between urban and rural areas, genders, age groups, racial groups, etc.

As grim as these figures are, they are misleadingly optimistic. Internet service in a low-income nation is, on average, far inferior to that in a high-income country. Broadband connectivity is rare, and poor infrastructure often results in substandard dial-up speeds and low reliability. Backbone networks are congested as are international links. As a result, the applications which are available on these networks are limited and more difficult to use. An Internet user on a slow, unreliable dial-up connection in a low income nation may be limited to character-oriented applications. Even simple Web browsing may be impossible. The Internet experience in a low-income nation is qualitatively different than in a developed nation.

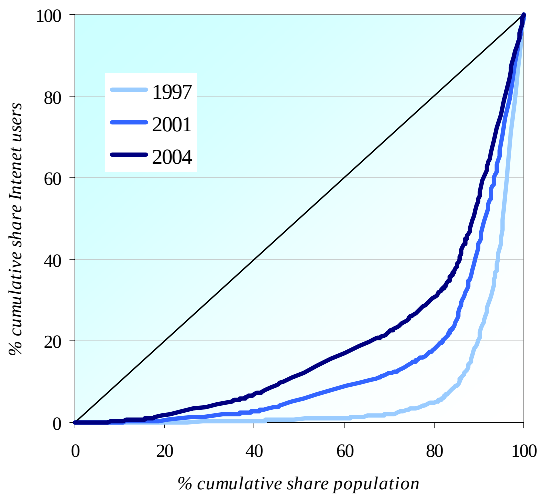
The cost and performance drawbacks are mitigated somewhat by the fact that many people use the Internet in shared facilities; however, even then the performance and reliability is not comparable to the mediocre broadband service in the United States, not to mention the high-speed service available in several European and Asian countries.

The poverty in the low and lower-middle income countries also cuts ICT diffusion indirectly by lowering levels of health care, education, and the viability of effective, transparent legal and government institutions. The direct and indirect impediments to diffusion result in a situation where anticipated returns are insufficient to attract capital to build networks in these countries.

2.3. Lorenz curves and Gini coefficients

Lorenz curve and Gini coefficients were developed to measure income inequality, but they can also be used to compare cumulative shares of ICT facilities and utilization. A Lorenz curve for Internet users is illustrated in Figure 6.

Figure 6. Lorenz curve for Internet users

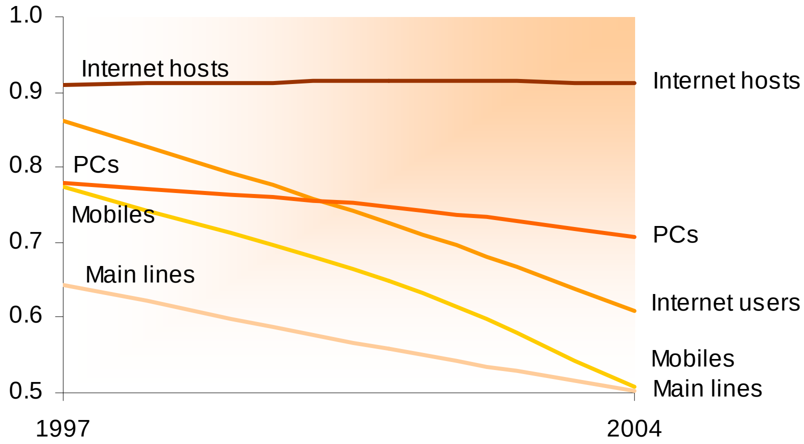


Source: Authors' calculations.

We see that in 1997, 80 per cent of the population accounted for only around 5 per cent of Internet users.[10] The Lorenz curves for 2001 and 2004 are above those for 1997, indicating increasing equality with time. If the rate of Internet use were the same in every nation, the Lorenz curve would reach the dark 45 degree diagonal line. The Gini coefficient summarizes the Lorenz curve in a single number, the ratio of the area between the Lorenz curve and the diagonal to the total area under the diagonal. As such, perfect equality would result in a Gini coefficient of zero and perfect inequality, a Gini coefficient of 1.

Figure 7 shows the Gini coefficients for several ICT indicators.

Figure 7. Gini coefficients, 1997-2004



Source: authors' calculations.

We notice that with the exception of Internet hosts, Gini coefficients have declined during this period, indicating increasing equality. It is interesting that the Gini coefficient for Internet users is dropping faster than for PCs. The PC predates Internet access, which was just taking off with the general public in 1997 even in developed countries. The cost of a new Internet account is also less than that of a PC, and many people in developing countries use the Internet in shared facilities.

The mobile phone Gini coefficient is also dropping more rapidly than that of mainlines. Again, the cost of a mobile phone is less than having a mainline installed. Mobile phone diffusion in developing countries has been spurred by the availability of pre-paid calling plans and by the practice of billing the calling party. Mainline installations often have a significant waiting time in developing countries and the customer must be credit worthy. Although mobiles may be shared, for example in micro-enterprises in rural villages, mainline telephones are more likely to be shared as in Indian public call offices.

[10] Our unit of analysis is a nation state. The curves are based on the populations and adoption levels in each nation.

Internet hosts is the only indicator for which the Gini coefficient is not falling. Part of the explanation is that hosts are commonly registered in generic top-level domains like *com*, *org*, *net* or *edu* rather than country domains like *cl* or *us*, and the statistics are based on these top level domain names. Furthermore, people in low-income countries who wish to reach a global audience have an incentive to place content on servers in high-income countries with fast, reliable connectivity and relatively low prices. Doing so may even improve domestic access. These factors inflate the disparity between low- and high-income countries on this indicator. On the other hand, it ignores the many million computers that share a single external address inside the firewalls of homes and organizations in high-income countries.

While declining Gini coefficients for all but hosts indicate increased equality, we should bear in mind that the disparities are greater than they appear because Internet users, PCs, mainlines and mobiles are not the same in high-income and low-income countries. Internet use is more likely to be in a shared facility in a low income nation, and, as we have noted, less reliable and slower. A PC is likely to be older and less powerful in a low income nation and more likely to be shared at work or school. Mainlines in high-income countries are, on average, more reliable than in low-income countries and are typically installed without delay. Although mobile phones are diffusing rapidly, fast, data-capable third generation mobile networks are less common in low-income countries.

2.4. Internet backbone capacity[11]

In early 2000, international bandwidth devoted to Internet traffic surpassed the bandwidth devoted to voice and private line networks. By 2005, it exceeded the others by a factor of more than six to one. Therefore, we can get a fairly complete picture of the digital divide by observing international Internet bandwidth capacity alone.

Table 7. Interregional Internet bandwidth 1999 and 2005

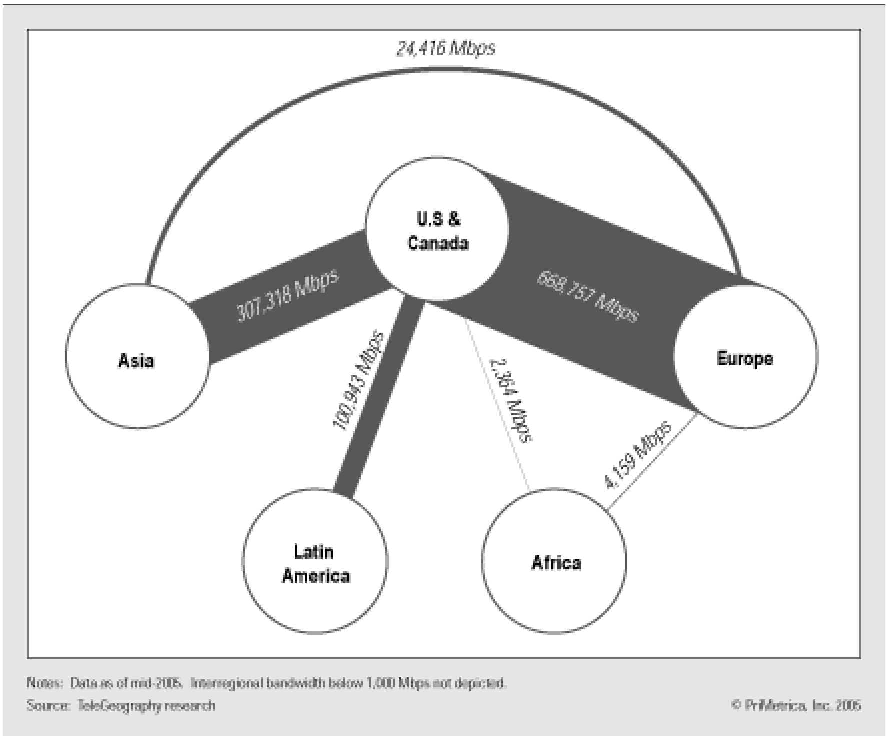
Regions	1999		2005	
	Mbps	Percentage	Mbps	Percentage
Africa-Asia	0	0	359	0
Africa-Europe	62	0	4 159	0
Africa-US and Canada	145	1	2 364	0
Asia-Europe	172	1	24 416	2
Asia-US and Canada	6 267	32	307 318	28
Europe-Latin America	63	0	8	0
Europe-USA and Canada	12 164	61	668 757	60
Latin America-US and Canada	953	5	100 943	9
Total interregional bandwidth	19 825	100	1 108 323	100

Source: Global Internet Geography (2006).

Table 7 shows that bandwidth between the United States and Canada and Europe and Asia far exceeds that of routes between other regions, and that the disparity has remained fairly constant between 1999 and 2005. Figure 8 illustrates the imbalance as of 2005.

[11] The data presented in this section was derived from Global Internet Geography (2006).

Figure 8. Interregional Internet Bandwidth, 2005



If we consider the disparity within the regions, the divide is even deeper. For example, the majority of interregional bandwidth in Africa is to Egypt and South Africa, the majority in Latin America is to Brazil, Chile, Peru and Argentina, and the majority in the Asian region is to Japan, Republic of Korea, Taiwan Province of China, Hong Kong (China), Singapore and Australia.

Table 8. Intraregional Internet bandwidth as a percentage of total international bandwidth

Region	1999 (in per cent)	2005 (in per cent)
Africa	0	1
Asia	6	35
Europe	70	72
Latin America	5	12
US and Canada	28	21

Source: Global Internet Geography (2006).

Table 8 shows the percent of international capacity within the regions as a percentage of the total international capacity (within and outside the region). We note that 72 per cent of European international capacity in 2005 is between European countries, while bandwidth among African countries only represents 1 per cent of international capacity. All international African traffic is routed through countries outside Africa. The same is true to a lesser extent for Latin America, but we do note an increase between 1999 and 2005 indicating that some international links have come online within Latin America. While not shown in these tables, a good deal of traffic between African and Latin American countries is also routed through Europe and the United States and Canada — an e-mail sent from one side of town to the other may travel many thousand miles before reaching the intended reader.

The same pattern is clear when we consider links between specific cities. Telegeography has compiled a list of the 50 highest capacity international links. With the exception of the link between San Francisco and Tokyo, the top 25 links are between city pairs in the US, Canada, and Western Europe. The only non-OECD cities in the top 50 are Hong Kong (China) and Sao Paulo (Brazil).[12] The 50 highest capacity Internet hub cities are also almost all in the US, Canada, Europe or the Asian Tigers. No African cities are in the top 50, but four South American cities and three Chinese cities rank between 34th and 50th.

[12] The link between Sao Paulo and Miami ranks 41st and is the only one in the top 50 in South America, Africa or Asia outside of Hong Kong (China), Taipei (Taiwan Province of China), Tokyo and Seoul.

3. CASE STUDIES

This section presents case studies of China, Chile, Botswana, Singapore, India and the United States. These countries were selected because they have had success blending ICT liberalization — privatization, competition and independent regulation — with responsible government planning, investment and procurement. We do not hold these nations out as total 'success stories' to be mechanically emulated — any such attempt would require oversimplification — we mean to highlight instances in which government have led to improvements. We briefly outline the broad political and economic context in which telecommunication policy has been formed in each nation, describe that policy and examine some of the results.

3.1. China: an eclectic ownership and competitive strategy

In 1990, the Chinese and Indian telephone systems were comparable. They had essentially equal teledensities of .6 per hundred capita, ranking them 159th and 160th among countries. China has progressed faster than India since that time. A decade later, China's teledensity was 17.8 and Indian 3.6 and their ranks had improved to 95th and 145th (ITU, 2002). By 2003, China's teledensity stood at 22.1. No simple explanation can be found for China's progress, but three contributing factors stand out, namely: a general opening of the Chinese economy, government emphasis on telecommunication as strategic infrastructure and the introduction of varying degrees of competition at different levels (Press *et al.*, 2003).[13]

In the late 1980s, China reoriented its economy, moving toward open markets. The results have been dramatic. GDP per capita rose from $1,596 in 1990 to $5,085 in 2004, and Barboza and Altman (2005) report that these figures are conservative.[14] Over the same period imports, exports and foreign direct investment (FDI) rose by over 9.9, 16.8 and 12.4 times, respectively.[15]

During the 1990s, China's industrial policy focused on infrastructure and high technology (Pangestu, 2002). By 2003, Chinese ICT expenditure per capita was 2.75 times that of India (World Bank, 2006). The Chinese government is known to rapidly implement any decisions it takes: in 1996 when the Chinese State Council took the decision to allow the Internet and to connect all provincial capitals, there were competing ISPs in every capital within a year.

China has followed a strategy of allocating resources to competing state-owned enterprises. In an effort to spur growth and efficiency, in 1994 China established Unicom as a competitor to the incumbent, China Telecom. However, China Telecom maintained a political advantage since they were a part of the Ministry of Posts and

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[13] This is not to imply that India has not made progress during this period, but they have not kept pace with China.

[14] Constant 2000 international dollars, World Bank (2006).

[15] The FDI figure is for 2003, the others are for 2004, World Bank (2006).

Telecommunications (MPT). The dual role of MPT as both a competitor and regulator has led to a conflict of interest and China Unicom shareholders pressed for separation.

The need for a new regulatory system and a coherent strategy for network investments led to the creation of the Ministry of Information Industry (MII) in 1998; this was done by merging the MPT and the Ministry of Electronic Industry. The MII is in charge of the development strategy and regulating telecommunications, broadcasting, satellites and the Internet. The MII is also charged with the establishment of a nationwide multimedia network to prevent duplication of investments.

In 1999, the MII split the former China Telecom into four independent groups (China Telecom, China Mobile, China Satellite and Guo Xin Paging Company for radio paging), easing regulation so that they would compete with other operators in the future. China Telecom's operations were separated from MII's regulatory activity and were split into northern and southern companies in 2001 (People's Daily, 2001).[16] Incentive contracts based on objectives and results (quality, traffic, revenue, etc.) were implemented for the Directors of the provincial Posts and Telecommunications Administrations, and the Chinese government started to decentralize administrative authority. As we noted, this strategy has worked well. Its efficacy has also been noted by the ITU:

> "The main form of competition has been between ministries of the government … although it is unlikely that this form of competition between state-owned enterprises would feature in many economics textbooks, it has proved remarkably effective. The key underlying factor is the will of the state to invest in and prioritize telecommunication development" (ITU, 2002).[17]

Chinese universities began using the Internet in 1994,[18] a relatively late date. After a delay to weigh the economic opportunity afforded by the Internet, the Chinese made the Internet a priority. By that time, economic openness and early investment in infrastructure paved the way for rapid Internet penetration.

The Chinese employed a mixed ownership strategy with regard to the ISP industry. Backbone networks were operated by state-owned enterprises, but not local access. By the end of 1999, there were over 500 local ISPs and they behaved like free market organizations, with many going out of business and attendant lay-offs. China has also pursued a mixed ownership strategy with respect to Internet exchange points (IXs). Early Internet traffic was routed through the National Science Foundation backbone in the United States, but the Chinese government encouraged the formation of IXs to handle domestic traffic. By 2002 IXs and domestic bilateral exchange points had the capacity to handle 84 per cent of Chinese traffic, indicating that China has weaned itself from the US and other foreign backbones.[19]

[16] People's Daily, State Council Approves China Telecom's North-South Split Plan, 12 December 2001, see http://english.peopledaily.com.cn/200112/11/eng20011211_86402.shtml.
[17] ITU, World Telecommunication Development Report, 2002.
[18] For dates of the first IP connectivity of nations, see http://www.nsrc.org/oclb/msg00048.html.
[19] CNNIC. Available at: http://www.cnnic.net.cn/mapinfo/english/cnnic-english.html.

Voice over Internet Protocol (VoIP) is a critical technology for developing countries with low teledensity and income and large expatriate populations;[20] however, it is often resisted by powerful incumbent telephone companies which fear revenue loss. The Chinese government concluded that the benefit of low-cost telephony would offset revenue cuts and encouraged VoIP. By 2002 at least four major networks, China Telecom, China Netcom, China Unicom and China Mobile offered VoIP (ITU, 2002). Embracing VoIP has paid off by cutting communication cost for businesses and individuals and by strengthening the competitors to China Telecom which tends to level the playing field.

Another area in which the Chinese government has acted decisively is in encouraging the adoption of Internet Protocol version 6. This will stand them in good stead as mobile devices and sensors proliferate on the Internet.

China has made remarkable progress with rapid telephone, mobile and Internet growth. That being said, we must bear in mind that they remain on the wrong side of the global digital divide and, like all developing countries, they face domestic digital divides, for example between eastern and western regions and rural and urban areas.

3.2. Chile: competition with government planning and applications

Chile was the first Latin American nation to privatize and liberalize telecommunication. In 1988, the Chilean telephone company was sold to Spanish and Italian companies for $478 million or $1,400 per line (Reed, 2005), and full competition was achieved by 2000 (Wellenius, 2001).

The results have been striking. In 1990, Chilean teledensity was 6.7 per 100 people, ranking them 93rd in the world. By 2000 it had increased to 44.4, 61st in the world. Only seven nations improved more rapidly than Chile during this period (ITU 2002). Table 9 shows improvements in teledensity and efficiency after privatization and liberalization.

Table 9. Chilean teledensity and efficiency after privatization and liberalization

	1988 privatization	1994 full competition	2000
Main lines, per 100 inhabitants	.6	1.6	3.2
Mobile customers (in millions)	0	.1	2.8
Total connections (in millions)	.6	1.7	6
Per 100 inhabitants	5	11	39
Outstanding applications (years)	7	.7	<.1
Telephone digitalization (% lines)	38	100	100
Main lines per employee	74	208	223
Households with telephone (%)	16	40	74

Source: Wellenius (2001).

[20] IP telephony to have a dramatic impact on Asian voice and data communication markets. Available at: http://www.isoc.org/oti/articles/0601/rao3.html.

In spite of this progress, Chile's rural and poor urban areas lacked service. In 1994, most rural inhabitants still lived in areas without even a pay phone. In striving for universal service, governments often require operators to cover rural areas as a licensing condition or charge a universal service fee to subsidize poor areas. The Chilean government used a market mechanism for universal service, implementing a successful programme in which providers bid for the subsidy they would require to cover a remote area (Wellenius, 1997).

Today, Chile ranks first or second among South American countries in nearly all per capita telecommunication indicators, including fixed and mobile subscribers, Internet users, personal computers, cost of calls and Internet access (World Bank 2006). Chile's ICT Diffusion Index is the highest in Latin America; Minges (2005) shows that Chile leads Latin America on five other e-indices.

Chile has set ambitious goals for the Internet. In 2004, Chile published a national plan — the Digital Agenda — the fruit of public-private consensus on the goals to be reached by the Chilean bicentennial in 2010 (Grupo de Acción Digital, 2004), these include:

- a reliable, secure wide-band infrastructure throughout the nation with access for every Chilean from their homes, work places, schools or info-centres and cyber-cafes;
- a digitally literate population and workforce;
- an online state, providing e-government information and service at the national, regional and municipal levels;
- digital business development with intensified use of the Internet in business and e-commerce;
- a critical mass of internationally competitive information and communication technology businesses; and
- a legal framework that assures freedom of expression, democracy, transparency, and access to knowledge and culture, while protecting the rights of creators and innovators.

The Digital Agenda also defined an action plan with 34 initiatives to work toward these goals during 2004-2006. Chile already has achieved considerable success. Let us consider examples in e-government, education and community access.

E-government

The e-government emphasis evidenced by the Digital Agenda has paid off. The UN has surveyed e-government readiness and compiled an e-government readiness index (ERI), which is a composite measurement of the capacity and willingness of countries to use e-government for ICT-led development (United Nations, 2004). The ERI is intended as a measure of governmental success in using ICT for the economic, social and cultural empowerment of its people. It combines an assessment of government website development with access characteristics such as infrastructure and educational levels.

Chile's ERI of 0.684 places the country in 22nd place out of 191 — the highest ranking in Latin America. The next three in the region are Mexico (0.596), Argentina (0.587) and Brazil (0.568), and the regional average is 0.4558. If we only consider website development — leaving out access and infrastructure — Chile holds sixth place in the world. The report also singles out 23 e-government best practices, and three of them are Chilean.

Chile is credited with leading an emerging trend in Latin America to provide both useful content and online service via an effective user interface at a government portal:[21]

> "Simplicity summarizes Chile's approach to e-government. The country homepage provides citizens with direct access to a variety of online services and information, including a National Online Employment Database and an Interactive Consumer Affairs Centre. In addition to direct links to these services, Chile's homepage provides user-friendly information on the President's daily agenda, one-click access to current legislation and important documents, easy access to regional governments and national ministry sites, and the list of services goes on and on. While many country websites provide this information, Chile has tailored the national homepage so that all online services and critical information are citizen friendly and one click away" (United Nations, 2004).

Education

In 1992, Pedro Hepp and his colleagues at the Catholic University began a project to develop and evaluate an elementary school network called "Enlaces" (links in Spanish). They began with only 12 schools, but their goals were to enhance efficiency, quality and equity in education and to "integrate the children into the culture." By 1995, with assistance from the World Bank, they had established 144 schools, each of which had a local Ethernet with between 3 and 10 computers and were providing a variety of services including student and teacher newsletters, educational software, curriculum notes, computer conferences, e-mail and database access (Press, 1996-a). Table 10 shows that today there are over 9,000 "Enlaces" primary schools (Delgado, 2005).[22]

These statistics do not tell the entire story. "Enlaces" has built an effective organizational structure with universities responsible for schools in their regions. They are organized in a two-tier geographic structure with directors from six universities and unit heads below them. Most of the unit heads are also from universities. They emphasize teacher training, content development and the integration of IT into the curriculum. Enlaces facilities are also opened to the general community after school hours (see below). They are also committed to geographic

[21] Spanish, http://www.gobiernodechile.cl, and English, http://www.chileangovernment.cl/, versions are available.
[22] 1499 secondary schools (85 per cent) also participate in the Enlaces network.

dispersion. Chile is divided into 13 geographic regions, ranging from the world's driest desert region in the north to near the Antarctic Circle in the south. Enlaces covers over 90 per cent of the students in all but three regions, the northernmost region (88.5 per cent), the southernmost region (84.3 per cent) and the metropolitan region (MR) which covers the capital Santiago (89.5 per cent).

Table 10. "Enlaces" primary school statistics, 2005

Schools	
Rural	4 726
Urban	3 183
Total	7 909
Children	
Urban	2 345 307
Rural	127 742
Total	2 473 049
Trained teachers	101 081
Total number of PCs	75 711
Internet connectivity	
Analog modem	2 578
Broadband	3 151
Total	5 729
Investment 1995-2005 (1,000 Pesos)[23]	
Total	117 799 680
Average annual investment	10 709 062

Source: Delgado, 2005.

Finally, as with e-government, Chile has a comprehensive education Web portal with information, tools and services for students, teachers, administrators, researchers and the family.[24]

Community Access

Both a 2001 presidential directive and the Digital Agenda committed Chile to universal access to and broad application of ICT. To this end, the sub-secretary of telecommunication (SUBTEL) has established an office for the coordination of all infocentres (SUBTEL, 2004; SUBTEL, 2005).[25] As of May 2005, there were 767 infocentres run by 12 government and private organizations, including Enlaces schools (after school hours) and public libraries. Since they are run by different organizations and are in different locales, the staff, facilities and equipment vary, but together they provide 2,808 Internet-connected PCs and have been used by 460,853 users.

SUBTEL also coordinates the work of 18 application and content providing organizations. These are diverse groups of educators, government agencies, and those

[23] The investment is shown in Pesos, and the conversion rate varies, but the total for the 11 years has been around $200 million and the annual investment has been around $20 million during recent years.
[24] http://www.educarchile.cl/home/.
[25] The infocentres are heterogeneous as they are operated by different organizations, but all provide shared Internet access.

working with youth, women and the poor. For example, Enlaces, the libraries and others offer digital literacy classes. Over 500,000 people have completed these 18-hour classes which are typically offered on weekends and evenings.

The Digital Agenda calls for gender and age equity, and 70 per cent of the after-hours users at Enlaces schools are women, and 50 per cent are housewives who were probably introduced to ICT by their children who were students in Enlaces schools. Fifty four percent of the users are between 30 and 59 years old. The majority of library infocentre users are also women.

The Digital Agenda also calls for geographic equity. Table 11 (Statoids, 2006; SUBTEL, 2005) shows that sparsely populated rural regions have more infocentres and PCs per capita than the metropolitan region (MR) which includes the capital Santiago or even other regions with large cities (Statoids database, 2005).[26]

Table 11. Infocentre distribution from north to south.

Region	Population (2002)	Population/ per square km	Centres 2005)	PCs (2005)	Centres/ 100,000 inhabitants	PCs/ 100,000 inhabitants
I	428 594	7.38	25	104	5.8	24.3
II	493 984	3.94	24	120	4.9	24.3
III	254 336	3.25	22	97	8.6	38.1
IV	603 210	15.21	33	171	5.5	28.3
V	1 539 852	94.02	57	259	3.7	16.8
VI	780 627	48.94	46	169	5.9	21.6
VII	908 097	29.76	70	294	7.7	32.4
VIII	1 861 562	51.70	104	422	5.6	22.7
IX	869 535	26.78	86	372	9.9	42.8
X	1 073 135	15.54	53	234	4.9	21.8
XI	91 492	0.85	14	54	15.3	59.0
XII	150 826	1.34	20	98	13.3	65.0
MR*	6 061185	384.06	118	486	1.9	8.0
National	15 116 435	20.51	672	2880	4.4	19.1

* MR, the metropolitan region, is in the centre of the country and contains the capital, Santiago.
Source: SUBTEL and Statoids (population).

In addition to working with provider organizations, SUBTEL holds monthly meetings for infocentre operators, maintains a website[27] with information on the programme and an infocentre database and publishes semi-annual progress reports.

Chile's newly elected president Michelle Bachelet promises to continue ICT progress. Immediately after her election, she established a Digital Agenda blog with the slogan "four years to digitize Chile" and arguing the benefits of such things as open source software, the use of creative commons licensing,[28] developing e-government, and improving Internet access.[29]

[26] This may partially reflect higher incomes and therefore greater household PC penetration rates in the urban areas.
[27] Available at: http://www.infocentros.gob.cl/red/inf_index.htm.
[28] Chile's determination to take a lead with respect to intellectual property is reflected in the Chilean WTO Commission's WIPO proposal on the importance of public domain information and its role in development on January 9, 2006, http://www.wipo.int/edocs/mdocs/mdocs/en/pcda_1/pcda_1_2.pdf.
[29] Available at: http://www.bacheletdigital.cl/.

3.3. Botswana: an effective, independent regulator

As in Chile, broad political and economic factors created an environment suitable for telecommunication growth in Botswana. At the time of independence, Botswana was a landlocked nation roughly the size of Texas, had only 12 kilometres of paved roads and only 22 university and 100 secondary school graduates. Between 1965 and 1998, GDP grew at 7.7 per cent per year, and per capita GDP was $8,716 in 2003 making it the third highest in sub-Saharan Africa which averages only $1,856 per year.[30] Botswana achieved this rapid development by following appropriate economic policies (Acemoglu *et al.*, 2001). Gwartney *et al.* (2005) rank Botswana's economic freedom as the 30th among all countries, making them the African leader (Gwartney *et al.*, 2005).

From 1980 to November 1995, Cable and Wireless was the sole provider of telecommunication service in Botswana. When that contract expired, the Botswana Telecommunication Authority (BTA) was established as an independent regulator with a mandate to restructure and introduce competition in the telecommunications industry. In 1998, they broke the telephony monopoly of the Botswana Telecommunications Corporation (BTC) by licensing two mobile operators. By 2004, BTC still had a fixed line monopoly, but the mobile operators had 80 per cent of the total telephony market. In addition to these, there were 35 licensed providers of Internet and data services and private telecommunications networks.[31]

In 2001, the ITU selected Botswana for a case study in effective regulation, stating that:

> "Botswana has won a well deserved reputation as one of the first countries in the African region to establish an independent and effective regulatory body. In fact, its level of independence and effectiveness may develop as a world model. BTA is one of the few regulatory bodies that enjoy complete freedom in licensing operators and in establishing and financing its operational budget" (ITU, 2001-a).

The ITU (2002) characterizes the BTA as:

- Completely free in licensing operators and establishing its own budget;
- Consultative and open with public meetings in all major cities;
- Independent, for example, refusing a mobile license to government-owned BTC;
- Consistently investing in human resource development and gender equality (Gillwald, 2005).[32]

[30] It must be noted that GDP growth has outpaced human development. Botswana's GDP per capita ranks 61st among nations and is 131 on UNDP's Human Development Index. No other nation has such a great gap.
[31] BTC was not granted a mobile license, which weakened it significantly and has hindered privatization. We do not know how many of the 35 non-telephony licensees are operating. These are smaller but generally more competitive markets than telephony.
[32] Twenty-eight BTA employees have postgraduate qualifications and 16 of those were acquired through BTA's sponsorship (Gillwald, 2005).

There is some concern that the BTA may not be able to maintain its independent role as the Telecommunications Amendment Act of December 2004 transferred some of their authority to the Ministry of Communications, Science and Technology (Gillwald, 2005). On the other hand, the BTC is due to be privatized this year.

Table 12. Botswana's teledensity per 1,000 inhabitants.

	1900	1995	2000	2003
Mobile phones	0	0	121.73	297.07
Telephone mainlines	20.58	40.9	82.71	74.87
Total	20.58	40.9	204.44	371.94

Source: World Bank (2006).

Table 12 compares pre- and post-BTA teledensity. The sum of mobiles plus mainlines increased by just under 100 per cent between 1990 and 1995 and by just under 400 per cent between 1995 and 2000. Between 1995 and 2002 Botswana's Digital Diffusion Index ranking improved from 97th to 80th place. Only 12 countries improved by more. The Botswana e-Government Readiness Index and digital diffusion index were fourth in sub-Saharan Africa behind Mauritius, South Africa and Seychelles (0.426) (United Nations, 2004).

Table 13. Telecommunication indicators per 1,000 people (World Bank 2006).

Botswana	1996	2003
Mobile phones	0	297.07
Telephone mainlines	48.32	74.87
Internet users (2002)	1.67	34.88
Sub-Saharan Africa		
Mobile phones	1.81	51.27
Telephone mainlines	11.75	10.67
Internet users (2002)	.57	16.96

Source: World Bank (2006).

Table 13 shows that Botswana has experienced impressive growth in most telecommunication indicators during the tenure of the BTA.

3.4. Singapore: government planning and participation pays dividends

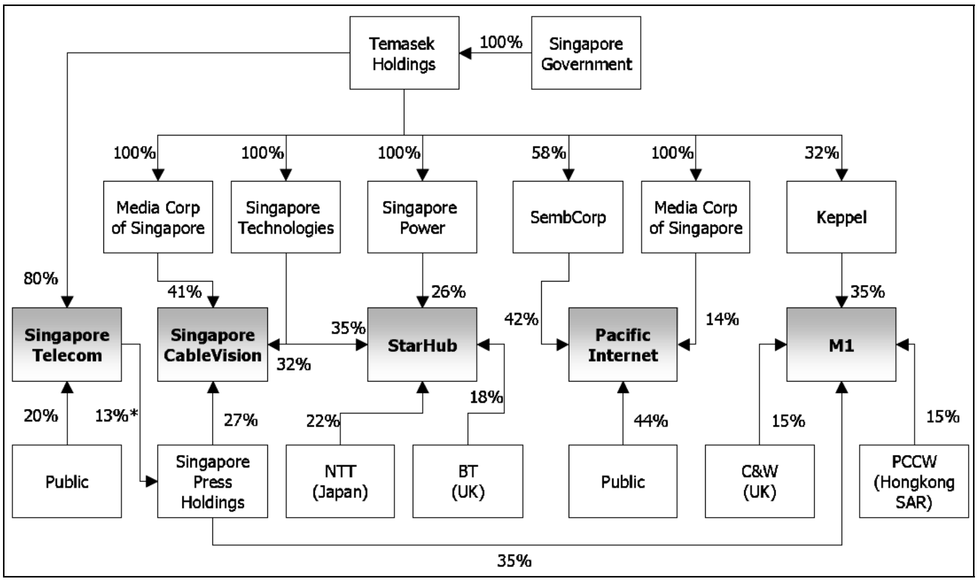
In 1965 when Singapore separated from Malaya (later Malaysia), it was an impoverished developing nation with a strong leader, Cambridge-educated Lee Kuan Yew of the People's Action Party (PAP). Mr Lee stepped down as prime minister in 1990, but the PAP remains in power. The PAP has successfully blended government control with a market economy, leading Singapore to a 2003 GDP per capita of $24,481 (21st in the world) and an HDI of .907 (25th in the world).

Since its formation, the government focused attention on key industries, and, by the mid-1970s, Singapore was a leading oil refining, financial and shipping nation. The government turned its attention to IT, beginning with the 1981 Civil Service Computerization Programme. In 1986, a Committee on National Computerization was formed to create a national IT plan. In 1992, they published their IT2000 which has been continuously updated in a series of Infocomm Technology Roadmaps.[33]

The IT2000 plan called for the construction of a broadband networking infrastructure, common networking services (e.g. directories, security, authentication and billing), experiments with applications (national IT application projects), forging international strategic alliances with industry leaders in Japan, the EC and the US, and establishing a policy and legal framework on issues such as data protection, privacy, copyright and intellectual property rights, and the admissibility of computer-imaged documents in court. This led to the construction of Singapore ONE, the national backbone and the Singapore Internet Exchange, which provides peered connections for major networks within and outside of Singapore, and sells connectivity to smaller, downstream ISPs in the region. Singapore's infrastructure planning was complemented by government programmes designed to attract investment in applications to run over Singapore ONE and the Ministry of Education Master Plan for integrating networked computers at all levels of the school curriculum.

The Singapore government is not only a passive planner, but is active in procurement and as an investor. For example, the major ISPs invested in Singapore ONE in response to government commitments to income-generating online services. Furthermore, the government owned equity in those ISPs. As Figure 9 shows, the government owned significant shares of the major ISPs Singapore Telecom, Pacific Internet and Star Hub at the time Singapore ONE became operational (Minges *et al*., 2001). We also see that the government held equity in television (Singapore CableVision), telephony (Singapore Telecom) and mobile phone (M1) companies.

Figure 9. Percentage of government ownership in key ICT companies in 2001



Source: Minges *et al.* (2001).

[33] http://www.ida.gov.sg/idaweb/techdev/infopage.jsp?infopagecategory=articles:techdev&versionid=1&infopageid=I3344. Singapore is currently embarking on plans for a "next generation national infocomm infrastructure" as part of their national plan for the year 2015, http://www.ida.gov.sg/idaweb/marketing/infopage.jsp?infopagecategory=&infopageid=I3762&versionid=4.

While the government was actively involved in planning and investing in ICT, telecommunication markets were liberalized. Infocomm Development Authority of Singapore (IDA) (2006) lists 45 "key liberalization moves since 1989", leading up to the announcement of full competition in the telecommunications sector in January 2000 (IDA, 2006). Competitive pressure resulted taking that step two years before originally planned.

This combination of expert government planning and investment combined with free market competition has served the Singapore well. They are ranked 16th on the Internet Diffusion Index, and rank even higher on each of the indices tabulated in Minges (2005): *Digital Opportunity Index, (DOI)* (rank 7); *World Economic Forum Networked Readiness Index*[34] *(NRI)* (rank 1); IDC *Information Society Index*[35] *(ISI)* (rank 12); *ITU Digital Access Index*[36] *(DAI)* (rank 14); and *Orbicom Monitoring the Digital Divide*[37] (rank 13). Their average national rank on all of these indices is 10.5. Singapore ranks 5th in broadband penetration, reaching 60 per cent of the households (Point Topic, 2005-b) and some surveys report that up to 99 per cent of the population is covered by broadband networks. The number of broadband service vendors in Singapore rose from 200 as on 30 June 2003 to 300 as on 31 December 2003 (Point Topic, 2005-a).

The IDA has issued a request for proposals on implementation of their Next Generation National Infocomm Infrastructure plan. This will be a public-private partnership providing ubiquitous 1Gbps connectivity over fibre and a complementary high-speed wireless network. The IDA considers this necessary to remain competitive in Asia, and anticipates completion of the project by 2012.[38]

3.5. India: government led reform leads to growth and telecentre innovation

Like many developing countries, India has a protectionist past. Mahatma Gandhi's call for self-sufficiency was one of the hallmarks of the Indian independence movement.[39] A 1976 law limited foreign ownership of a business to 40 per cent, and IBM left India interrupting the deployment of mainframe computers. Rajiv Gandhi assumed leadership after the assassination of his mother in 1984 and identified telecommunications and information technology as a "core sector" along with traditional industries like power, steel, oil and automobiles, but telecommunication remained a government monopoly until the National Telecom Policy 1994 (NTP 94) allowed the entry of private companies.

Progress remained slow. Two mobile operators were licensed in each of 23 service areas, fragmenting the country so that by 1998 there were still only 1.217 mobiles and

[34] http://www.weforum.org/site/homepublic.nsf/Content/Global+Competitiveness+Programme%5CGlobal+Information+Technology+Report
[35] http://www.idc.com/groups/isi/main.html
[36] http://www.itu.int/ITU-D/ict/dai/index.html
[37] http://www.orbicom.uqam.ca/projects/ddi2002/ddi2002.pdf
[38] http://www.ida.gov.sg/idaweb/marketing/infopage.jsp?infopagecategory=&infopageid=I3762&versionid=4, http://www.ida.gov.sg/idaweb/doc/download/I3762/factsheet_NGNII030306.doc
[39] This background is based on Press *et al.* (1999) and Press *et al.* (2004).

21.985 mainlines per 1,000 people (World Bank, 2006), and wire line service continued to be dominated by the incumbents, as it is almost everywhere.

The election of the Bharatiya Janata Party (BJP) in 1997 signalled renewed interest in ICT. BJP listed ICT as one of the government's five top priorities. Mobile licence fees were dropped in lieu of 15 per cent profit sharing with NTP 99. This combined with falling capital and handset costs, prepaid calling, calling-party pays, increased competition from newcomers and wireline operators led to rapid mobile growth. By 2003 there were 24.747 mobiles per 1,000 people (World Bank, 2006). The wireline market has been slower to change with 46.284 per 1,000 people by 2003 (World Bank, 2006), but only 5.5 per cent were from private operators and the growth has been largely in urban areas (Jhunjhunwala *et al.*, 2005).

The history of the Internet is similar to that of telephony. India's education and research network (ERNET) was connected to the Internet as early as 1988. The government used the authority granted in the Indian Telegraph Act of 1885 to stop private ISPs from operating, so only government agencies were able to become ISPs serving limited constituencies, and the Ministry of Communication kept a monopoly over commercial ISP service.

Change began with the establishment by the BJP of a National Taskforce on IT and Software Development in May 1998 to formulate IT policy.[40] The Task Force acted quickly, releasing a 108-step IT action plan in July 1998, an IT action plan on the development, manufacture and export of IT hardware in October 1998, and a long-term national IT policy in April 1999. By 2002, Class A (all India) ISP licenses had been issued to 79 organizations, 357 licences had been issued for access in limited regions or local areas, and 20 companies had permission to operate 45 international gateways in 16 cities. Not all of these succeeded or even became operational, but the degree of interest was impressive (Mahanta, 2001). The Indian Internet has grown rapidly since that time. The number of Internet subscribers grew from 25,000 in 1997 to 6.674 million in 2005, a compound annual growth rate of 86 per cent (Nascom, 2005). India's success in supporting, among others, the outsourcing of call centres, software development, accounting and radiology analysis is widely documented.[41] However, nearly all of this growth and application has been in urban areas.[42]

India's Internet pilot studies and applications in rural areas are potentially more important for closing the digital divide than is their general telecommunication progress. Both the federal and state governments have called for universal rural connectivity and India has been a hotbed of telecentre development. Jhunjhunwala *et al.* (2005) surveyed ten telecentre projects (Table 14); and three of them, i.e. the MS Swaminathan Research Foundation (MSSRF) village knowledge centres, e-chaupal and n-logue are particularly noteworthy.

[40] For the description of the Taskforce and its history and reports, see http://it-taskforce.nic.in/vsit-taskforce/.

[41] Indian outsourcing began with software development in which they were an early mover, dating back to the work of Tata Consultancy beginning in 1974 (Press, 1993). This early start, combined with other factors including strong university and trade education, English language skill and an entrepreneurial culture led to success in software export and later to other forms of outsourcing.

[42] Internet service was available in over 400 cities by 2003 (Wolcott, 2005) but rural areas remain largely without service.

Table 14. Rural Internet projects in India.

Project	URL
Non Profit	
Bhoomi land record computerization	www.revdept-01.kar.nic.in
Warana wired village project	www.mah.nic.in/warana
Gyandoot	Taken over by n-logue
MSSRF village knowledge centres	www.mssrf.org
Akshaya IT dissemination project	www.akshaya.net
Project Rural e-Seva (e-services)	www.westgodavari.org
For Profit	
Drishtee	www.drishtee.com
TARAhaat	www.tarahaat.com
e-Choupal	www.echoupal.com
n-Logue	www.n-logue.co.in

Source: Jhunjhunwala *et al.* (2005).

M.S. Swaminathan is founder of the MS Swaminathan Research Foundation (MSSRF) which is internationally known for research on sustainable development. Swaminathan feels that policymakers must focus their attention on the poorest person before technological and information empowerment can reach those who can benefit from it (Swaminathan, 2001). In order to do this he launched the Information Village Research Project to study information uses and needs in villages (Press, 1999). This led to the establishment of MSSRF Knowledge Centres in rural Pondicherry. Their positive experience has led them to take the lead in Mission 2007, a consortium with the goal of "taking the knowledge revolution to all the more than 637 000 villages of India by 15 August 2007" in conjunction with the 60th anniversary of India's independence.[43] The coalition includes over 150 businesses and non-governmental organizations, and the Indian government has committed $23 million support for 2005–2006.

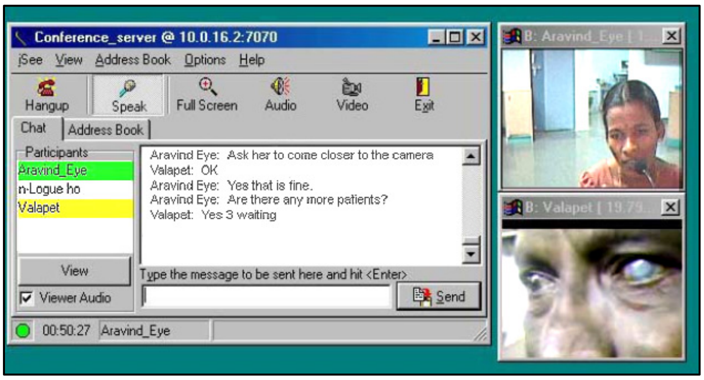
The MSSRF Knowledge Centres are non-profit, but two of the for-profit projects, e-chaupal and n-logue, are growing rapidly and have been independently evaluated and found to be sustainable (e-Chaupal: Annamalai and Rao, 2003, Rajashekhar, 2005, n-logue: Paul, 2004). They employ different business models.

Figure 10. Personal home page, e-chaupal[44]

[43] Available at: http://www.mission2007.org/
[44] Available at: http://www.itcportal.com/sets/echoupal_frameset.htm

The e-Chaupal[45] (electronic town square) business model is that of a single corporate owner operating Internet centres (Figure 10). ICT, an Indian conglomerate with holdings in hotels, agriculture and IT has established remote centres at agricultural hub locations, and is using the network for agricultural information and best practices, weather reports, supply chain support for farm inputs, direct marketing for farm products, and information on government programmes. ICT's investment is recouped in between 8 months and 2 years by savings in logistics and payments to agricultural middle men (Annamalai and Rao, 2003).

Figure 11. n-Logue eye examination using a low-cost Web camera and chat software[46]



n-Logue's rural information centres illustrate a second business model, franchising (Figure 11).[47] n-Logue provides connectivity, hardware and training to the local operator of a village centre and the centre offers computer training, local-language office productivity applications (word processing, spread sheet, database, e-mail client, Web browser and a drawing package), digital photography, desktop publishing, e-mail/voice and video mail, telephony, and access to government, medical, veterinary, and agricultural experts and information. The centre operator invests approximately $1,000 for a PC with a Web camera, printer, power backup, local-language software, and communication equipment. An Indian village averages roughly 1,000 people and the breakeven revenue for a kiosk is approximately $75 per month. Paul (2004) concludes in a case study that "n-Logue has developed a viable and scaleable model for delivering information-based services to rural areas" (Rajashekhar, 2005).

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45 Available at: http://www.itcportal.com/sets/echoupal_frameset.htm.
46 Available at: http://www.n-logue.com.
47 Available at: http://www.n-logue.com.

Figure 12. Television distribution in rural India[48]

Precedent, inspiration and experience for n-logue's approach may be India's ubiquitous Public Call Offices (PCOs) and village television distribution. The estimated 900,000 PCOs are typically operated by entrepreneurs who keep their storefront kiosks open 18 hours a day, 365 days of the year.[49] Television is also often downlinked and distributed through a local operator within a village (Figure 12).[50]

3.6. United States: the first Internet backbone

Including the United States, ranked second in the world on the ICTDI, as a case study in a report on the digital divide may seem strange, but the state of the Internet in the United States in 1989 was similar to that in developing nations today. There was no national backbone network, residential connectivity or commercial application. Only a few universities were connected to the Internet, and it was slow, with file transfer and character-based e-mail and network news being the primary interactive applications. The federal government played a key role in the research preceding the Internet and the construction of the first US (and later global) Internet backbone (Press, 1996b).

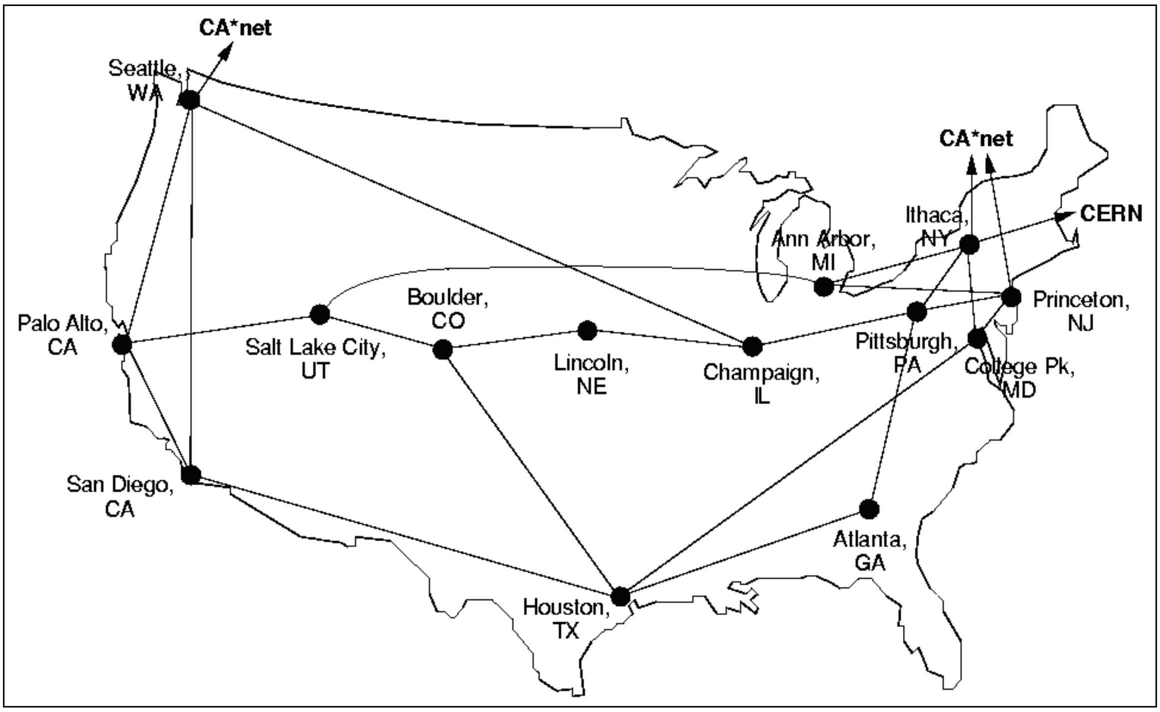
Previous experience with store and forward networks, the ARPANet and CSNET convinced the US National Science Foundation (NSF) of the feasibility and value of computer networks. They realized that a network connecting research and education institutions would increase their productivity and further the NSF mission. As such, they set out to build national Internet backbone and provided a high-speed communication link from that backbone to a point of presence (POP), which was then provided to any university in the United States.[51]

In 1988, the NSF established NSFNet, a 13-node backbone connecting large NSF-funded research computer centres (Figure 13). The initial links were only 50 kbps but the speed was soon increased to 1.4 Mbps and later to 45 Mbps. The network was

[48] MSSRF M.S. Swaminathan Research Foundation and published earlier by Press (2003).
[49] E-mail communication from Adite Chatterjee, 29 March 2005.
[50] In a 1998 interview M. S. Swaminathan emphasized the importance of entertainment in driving rural telecommunication.
[51] The POP was generally a Cisco router connecting the campus local area network to the communication link to the backbone network.

bought by NSF, but built and operated by contractors chosen through competitive bidding.

Figure 13. The NSFNet backbone in 1991 after it was upgraded to 1.4 mbps



Source: Merit Network, Inc.[52]

In addition to building the network, NSF assisted universities and research institutes to connect it to the network. Any university with a local area network could connect to one of the backbone nodes without charge. The NSF also paid for the communication link to the backbone node and a router on the campus, establishing an Internet point of presence (POP). They later encouraged foreign research networks to connect to the backbone. In addition to providing connectivity without cost, they negotiated special communication link prices on behalf of developing countries via competitive bids. Eventually, they assisted 28 foreign research and education networks with connectivity, making NSFNet the first global Internet backbone. Three NSF policies contributed to the success of the network.

The network was highly leveraged

NSF built the backbone and provided to each university a $20,000 grant for a router and connection assistance. The total cost of this program was under $100 million, but all it did was establish a network POP on the campus. It was up to the universities to equip staff and support their local area networks. The aggregate cost of building and operating those networks far exceeded the cost of the NSF backbone and their connection assistance programme.

[52] Merit is a non-profit organization governed by the public universities of Michigan and was the NSFNet operator.

Table 15. The cost of United States Government-funded network infrastructure projects

Project	**Cost (US$ million)**
Morse telegraph	.03
ARPANet	25
CSNet	5
NSFNet backbone	57.9
NSF US higher education connections	30
NSF international connections	6

Source: Press (1996b).

NSFNet and the networks that preceded it were regarded as research projects, conceived and designed by highly qualified researchers.

Although ARPANet, CSNet and NSFnet eventually went into production, they were applied research projects. At the time they were being designed, active debates were taking place on, among others, packet-switching vs. circuit-switching, OSI vs. TCP/IP, the separation of the network and transport layers. Routing algorithms and the domain-name system also remained to be invented.

Highly qualified researchers from leading universities and research labs were brought in to design and oversee the implementation of these networks. The work was not carried out by career government employees but by top scientists on temporary assignment. These scientists funded research and development with grants and oversaw network deployment once contracts had been awarded by competitive bidding.

NSFNet was an end-to-end network[53]

The NSF funded only the Internet backbone, and left the bulk of the funding to universities who built networks to connect to it. More important, application development was also left to the users. The network itself was designed to be simple and fast. Routing algorithms were used to move data packets from one computer to another, making a best effort to get them closer to their destination. The network ignored the content of those packets. They received the same treatment regardless of whether they contained music or pictures, e-mail messages or images from Mars, messages from children or messages from distinguished professors.

[53] This philosophy was an integral part of the design of the Internet routing protocol, see Saltzer *et al.*, (1984) and Isenberg (1998).

4. PROMOTING THE TELECOMMUNICATION SECTOR: LIBERALIZATION AND BEYOND

The latter part of the twentieth century witnessed a global trend away from protected, controlled economies toward open market economies. Telecommunication was included in this movement. There was a steady trend toward privatization of state-owned companies, openness to competition and foreign investment, and liberalization of regulation. The dominant telecommunication policy has favoured privatization, competition and independent regulation (PCR).

4.1. Privatization, competition and independent regulation (PCR)

PCR has been encouraged by the World Trade Organization (WTO). In February 1997, 69 WTO Member States agreed to open their telecommunication services markets. The agreement was signed by a mix of industrialized and emerging countries, which, according to the International Telecommunications Union (ITU), accounted for over 91 per cent of global telecommunication revenues and 82 per cent of the world's telephone main lines in 1995. By December 1998, there were 90 signatories, and the WTO reported that:

> "Under the stimulus of competition and changing technologies new services are constantly being developed … demand for and issues of licenses have increased dramatically. Competitors are prompting sharp reductions in prices of international and national long distance services … The clear prospect of competition has also further accelerated the pace of innovation, leading to new services that may have been difficult to foresee less than two years ago when the WTO negotiations concluded" (WTO, 1998).

As of July 1998, over 1,000 facilities-based international carriers were operational worldwide, compared to less than 500 just two years earlier. The ITU reported that by 2002, just over (56 per cent) of responding countries had either fully or partly privatized their incumbent telecommunication operator and those countries accounted for 85 per cent world telecommunication revenue (ITU, 2002). Competition was also increasingly allowed. By 2001, 37 per cent of countries allowed competition on long-distance calls, 38 per cent on international calls, and 43 per cent on local calls. Seventy eight percent of countries allowed mobile competition and 86 per cent allowed Internet competition. There were fewer than 200 mobile operators around the world in 1992 and by the end of 2001, there were over 600. The telecommunication industry had also become a global industry with many companies in developed countries have holdings abroad. The ITU summed the situation up as follows:

> "Four words sum up today's telecommunication market: *private, competitive, mobile* and *global*. The pace at which these have occurred is remarkable, that calls for liberalization of the industry are increasingly overtaken by reality."

The ITU stated what has become conventional policy wisdom, and they singled out our three PCR components: private sector participation, market competition and independent regulation. They advised that all three must be present, even if practical politics keeps them from occurring in the ideal sequence. Omitting one step completely was worse than doing it in the wrong order. For example, Botswana established an independent regulator in 1996 and began allowing competition in 1998, but is planning to privatize BTC this year. Along these lines, (ITU 2000) suggests that:

- Privatization without competition is good, but privatization with competition is better;
- Introducing private sector players is good but allowing them the freedom to compete is better;
- Creating regulators is good, but giving them adequate powers and independence is better;
- Creating a duopoly is good, but allowing open competition is better; and
- Introducing competition is good, but introducing it at an early stage is better.

To varying degrees, nearly all countries have moved toward telecommunication PCR during the last twenty five years. As a result, telecommunications witnessed dramatic improvement almost everywhere. Still, there are limits to the efficacy of PCR policies.

4.2. PCR policy limits

Each country is different in many ways, and a progressive telecommunication policy can be trumped by factors such as ineffective government agencies, recalcitrant incumbent operators and corruption.

Although many countries allow telecommunication competition, market structures vary. For example, competition might exist in mobile and Internet service but a single long distance carrier. Market freedom may also be constrained by vertical integration, with, for example, one company offering connectivity, Internet service and content or one ISP controlling a nation's international gateway. While competition may reduce prices, it may not be feasible due to the high cost of duplicating infrastructure and reducing economies of scale and scope.[54]

Privatization does not mean that the government has no role. A strong and independent regulator is very important. The regulator must have the resources to audit providers and create and enforce regulations that mitigate any inequity arising from integration and imperfect competition.

[54] Economies of scope refer to efficiencies associated with firm's diversification into several products. Economies of scope are conceptually similar to economies of scale, which apply to efficiencies associated with increasing the scale of production.

In addition to regulation, the government often plays a key role in planning and procurement, as illustrated in the case studies described above:

- Chile was the first country with PCR in South America. The government has also taken a leadership position in developing a comprehensive ICT plan, developing e-government services, a comprehensive school network and curriculum programme and coordinating telecentres.

- The Indian government convened task forces which led planning and reform, and both national and state governments have encouraged investment in infrastructure and supported efforts to bring telephony and Internet connectivity to rural villages.

- The Singapore government has played a major role in ICT planning and both made direct investments and encouraged deployment by developing and offering e-government services.

- In addition to planning ICT development, the Chinese government has allowed state-owned enterprises to compete with each other and has allowed competition among companies connecting to state-owned backbones.

- The National Science Foundation (NSF) in the United States seeded the Internet by building a backbone network and paying for connecting university and research networks to it.

We have witnessed strong growth in telecommunication under PCR policies, but it is difficult to determine what portion of that improvement is due to telecommunication policies and what part is due to broader economic policy and performance and technological improvement.[55] Comparing rank changes tends to isolate policy as countries that move up in rank are improving relative to countries with relatively similar economic situations and access to current technology.

PCR policies have had an overall positive impact, and there is still room for policies encouraging competition through open access to oligopoly-controlled infrastructure, but the digital divide persists. While foreign investment has been very important in some countries; in Chile, for example, it has not generally been sufficient to narrow the digital divide.[56] The situation does not appear to be improving. For example, the United Kingdom Department for International Development (Balancing Act, 2004) has estimated bandwidth demand based on a medium-growth scenario for sub-Saharan Africa and concluded that "under current conditions, there is almost certainly a shortfall in financing these projects." This conclusion is reached by extrapolating demand for today's low bit-rate applications. There is little hope for the more valuable

[55] See Lipsey (2000) for an economic-theoretic critique of policy which ignores the effects of endogenous technical change, the accompanying uncertainty (as opposed to quantifiable risk), and the complexities of production-facilitating structure (human capital, financial institutions, etc.), and existing public institutions and policies.

[56] The bulk of foreign investment has gone to large companies for privatization and mobile networks, encouraging oligopoly. As we have seen in the case of the attempted reform of United States telecommunication in 1996, large companies in oligopoly markets resist pro-competitive policies. Domestic investment may be more likely to go to small, competing service providers.

but resource-demanding applications of tomorrow. If PCR is not sufficient to close the digital divide, other complementary policies should be considered.

4.3. Beyond PCR

This section addresses public Internet backbones to provide neutral connection points for competing services. As indicated above, Internet communication protocols are intentionally simple, therefore allowing the transport of any type of data for any type of application. Since its inception, researchers have hypothesized that the Internet could improve quality of life in developing countries and that the impact might be greatest in rural areas, which have poor telecommunication and transportation infrastructure.[57] This hypothesis has inspired a great deal of work over the last 10-15 years.

During this time, thousands of networking leaders and technicians from developing countries have been trained and many national studies of policy and technical “e-readiness” have been undertaken. Importantly, pilot projects have demonstrated valuable applications in health and veterinary care, education, agricultural markets, transportation, entertainment and games, news, personal communication (text, voice, video) and e-government.[58]

Sprigman and Lurie (2004) suggest that Internet backbones should be nationalized in developing countries. They consider that publicly-owned backbones would level the playing field and increase competition among retail providers, leading to innovative services at lower prices. They are aware of the dismal track record of governments running telephone networks, but point out that a telephone network is complex while an Internet backbone is relatively simple.

Press (2004a, 2004b) considers this possibility in more detail and advocates the goal of building, at public expense, an Internet backbone in every developing nation and region, and providing a high-speed connection from the backbone to a POP with a power supply[59] in every rural village.[60] Wherever possible, fibre cables would follow roads, pipelines, railroad lines to villages. A terrestrial wireless mesh would reach the others (Press, 2003).

It should be noted that a high-speed network would encourage and enable applications that are not feasible today in developing countries. For example, downloading movies

[57] This hypothesis has been stated frequently, in many forms, by many people, for example, Sadowsky (1993) and Press (1995 and 1996).

[58] For descriptions of successful applications in developing nations, see:

- International Development Research Centre, http://www.idrc.ca/
- Digital Dividend Project, http://www.digitaldividend.org
- Information for Development Program, Infodev, http://www.infodev.org/
- Development Gateway, http://www.developmentgateway.org/
- Sustainable Development Networking Programme, http://www.sdnp.undp.org/

[59] Power is included in the definition of “point of presence.” As such, power engineering is one of the expertise areas listed below. MIT, IIT, Virginia Tech and others are sources of expertise, and a variety of solutions would have to be developed. This is a difficult challenge, but neither unprecedented nor insurmountable.

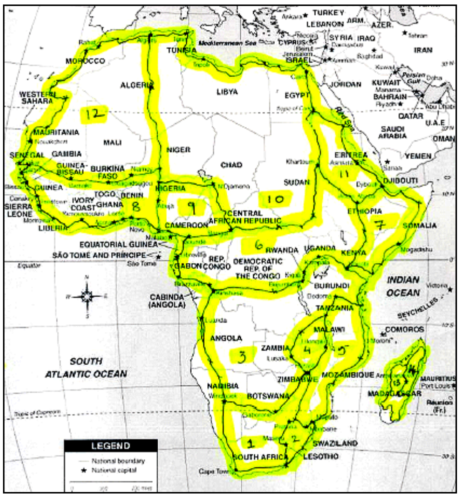
[60] Much of what follows in this section is based upon these two articles.

and other forms of entertainment would be practical. The medical diagnosis session illustrated in Figure 11 uses only low-resolution video and text chat. A high-speed network would support high–resolution video, high–fidelity sound from a stethoscope, EKG data and other diagnostic input such as the low-cost endoscope developed by a rural physician in the Mekong Delta (Le, 2005). There would also be capacity for many simultaneous VoIP telephone calls. The Indian and Chilean telecentres described above could evolve into village theatres, clinics and phone companies.

Necessity is the mother of invention: rural people in developing countries are likely to develop applications to solve their own problems using their resources and knowledge of those problems. Once completed, the network would serve as a platform for deploying and testing these applications. Of course the benefit of those applications, e.g. low-cost medical instruments such as the endoscope mentioned above, would accrue in both the developed and developing countries.[61]

Going beyond a single nation, Tongia (2005) has created a preliminary design for an African backbone. His high-level design calls for a 70,000 Km fibre core (Figure 14) with 30,000 Km of fibre spurs with terrestrial wireless technology linking the remaining villages to this fibre backbone.

Figure 14. Core fibre backbone for Africa[62]



Source: Tongia (2005)

National planning and investment must take place in the context of regional planning. For example, while the west coast of Africa has several fibre landing points, the east coast does not; however, the Eastern African Submarine Cable System (EASSy) is planned for East Africa.[63] EASSy, shown in red in Figure 15 is a proposed 8,000 Km cable that will connect East Africa to Asia. EASSy is scheduled to begin operation by the end of 2007, and, if successful, it will provide landing points networks such as the

[61] We are reminded of the story of the young mathematician Srinivasa Ramanujan who rose to fame after writing Professor G.H. Hardy at Cambridge from his village in Southern India. More information is available at: http://scienceworld.wolfram.com/biography/Ramanujan.html.

[62] The fibre core is shown in yellow, the spurs are not shown.

[63] Available at http://eassy.org/.

one proposed by Tongia. The latter's network would, in turn, provide connectivity for national backbones.

Figure 15. Proposed (red) and existing submarine cable serving Africa

Source: http://eassy.org

The initial investment anticipated by EASSy is $200 million. To put that in context, Tongia estimates his network would put an Internet POP within walking or bicycling distance of 400 million people at an estimated cost of one billion US dollars.

5. METHODOLOGY APPENDIX [64]

The Index of ICT Diffusion is designed to evaluate ICT development using indicators of ICT diffusion across countries. It measures the average achievements in a country in two dimensions:

- *Connectivity*, as measured by the number of Internet hosts per capita, number of PCs per capita, the number of telephone mainlines per capita and the number of mobile subscribers per capita. As such, it gives a measure of the infrastructure development.

- *Access*, as measured by the number of estimated Internet users, the adult literacy rate, the cost of a local call and GDP per capita (PPP US$). This component aims at describing the opportunity to take advantage of being connected.

An index score is calculated for each of these indicators by applying the following formula: value achieved / maximum reference value. Connectivity and access indices are then calculated as an average of index scores of their respective components and index of ICT Diffusion is itself an average of these two dimensions.

Appendix 1. 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”. This view of a cluster of technologies is consistent with that of the Mosaic Group, which 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 Kiviat or “wheel and spoke” diagrams (Press, 1999) 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 its “Framework Analysis” paper (1996) 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, that is countries exhibit different profiles across the spectrum of ICT technological capabilities. Press

[64] UNCTAD (2003).

(1999) notes further challenges for Internet indices, notably that 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 to offset one indicator with another (i.e. connectivity is assumed to be equivalent to access). GIT (2000) notes that an "additive model implies that strength on any one of these dimensions could compensate for weakness on another".

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, as above. This is also the perspective within which the idea of "leapfrogging" fits. 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. In fact, determinants do not have the same or equivalent influence over IT capability.

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, stating that a multitude of factors must be in place in order to take full advantage of the economic potential of the Internet, and that weakness in one area can seriously obstruct the realization of potential benefits. GIT (2000) also describes a synergistic view of technological development by highlighting the fact that all four dimensions in its model, namely national orientation, socio-economic infrastructure, technological infrastructure and productive capacity, have to be strengthened 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. UNCTAD also opts for such a model mainly for two reasons. First, our review of 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 because of its relative simplicity. UNCTAD uses the aggregated index approach, with component indices (similar to UNDP's Human Development Index). Countries' overall scores may be disaggregated into component indices of interest, permitting finer discernment between countries 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

The ITU 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. The 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" [italics added]. The 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. This method has the advantage that reference points derive from real-world achievements realized by any country. However, it has the drawback that reference countries change year on year, thus 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 report, UNCTAD adopts a comparative approach based on comparisons of relative country rankings between years to identify countries that are making progress in ICT uptake, and those that 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 countries 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 than about 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 in order 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 than about their absolute index scores.

Reference points

The question of approach in using relative vs. absolute indices is closely connected with 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 per cent literacy rate, 100 per cent Internet user rate. For other indicators, maximum achievements are less obvious. Mobile penetration may reach over 100 per cent (e.g. for subscribers with more than one phone, or two SIM cards per phone). There are no prior established 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 US increased [its electronics production] by $71 billion from 1996 to 1999. The position of the US is so strong that even China's remarkable doubling of electronics production from $33 billion to $65 billion increases its score only from 12 to 19" (out of 100).

Indicator scores methodology

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

Index score = (Value – Minimum)/(Maximum – Minimum)

Annex table 1 presents the index of ICT Diffusion calculated on the basis of the Connectivity and Access Indices for 2004.

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 to be equivalent to access). GIT (2000) notes 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) recognizes 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 recognizes 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".

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, 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 countries and territories as our unit of analysis gives added pre-eminence to Singapore, as both a nation state and a "large city" (ITU, 2001), compared with, for example, a lower ranking for India, comprising Bangalore as a technological hub. Very different results would emerge if New York or Bangalore were separated from their hinterlands. New York has more Internet hosts than the whole of sub-Saharan Africa, which means that a city ranking, or ranking countries by cities, would yield different results. The survey by Telegeography (2000) gives some indication of what a ranking by cities looks like.

Bridges.org (2001) 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 unit of analysis (i.e. the nation state) determines the choice of variables and method. The Mosaic Group (1996) measured the 'indigenization' of IT capability or "involvement by nationals…in installation, use, operation, maintenance, management and adaptation of technology…performed by indigenous personnel". Its later (1998) theoretical framework assesses absorption of ICT technologies as independent, stand-alone technologies. The 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 United States).

National size effects

GIT (2000) notes that Porter and Stern's innovation index "is normalized (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, it does not explore the consequences of this for its 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 the country. Further expansion of the network may result in economies of scale in larger countries, resulting in proportionately reduced levels of infrastructure per capita. Population dispersion and geographical dispersion of the network are intimately related to country size. It is unlikely that these effects can be corrected for; 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.

In fact, the most important consequences of using normalized per capita measures in our indices arise for developing countries. Where countries have high rates of population growth, indices based on per capita indicators of telecommunications development mean that any growth in telecommunications infrastructure must outstrip population growth to result in an improved indicator value and index score.

Data omission effects[65]

The treatment of data omissions is central in determining the results of an index. When a figure is missing for one or several years (but not all), it is replaced by the former year's figure. This choice appears more appropriate than simply adjusting the final score for the number of data observations: doing so would be tantamount to replacing the missing score for a single year by the average of the other variables scores, which would induce greater inconsistency from one year to another than the selected method.

When a figure is missing for all the years, final scores are adjusted for the number of data observations. However, data omissions are more likely for poorer countries. This poses a problem for our results, the extent of which is unclear. Rodriguez and 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.

Selection of the countries

The countries that have missing data (all years) for more than two out of the eight components of the ICT diffusion index are rejected of the rankings. Hence, 180 countries appear in the rankings.

Appendix 2. Definition of components

Connectivity

Connectivity is narrowly defined as the physical infrastructure available to a country, as distinct from broader factors determining access (e.g. literacy, cost). It represents the basic "limiting factor" regarding access to and use of ICTs — without the essential physical hardware, ICT use is not possible. UNCTAD defined narrow "connectivity" as the minimum set of measures necessary for ICT access, comprising Internet hosts per capita, PCs per capita, telephone mainlines per capita and mobile subscribers per capita. This excludes supporting infrastructure (such as electricity 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 notes 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 infrastructure. This is in contrast to UNDP's sequential

[65] The data omission policy was slightly different in UNCTAD (2003) and UNCTAD (2004).

logic of "old" (telephony and electricity) as opposed to "new" innovations (hosts, PCs) and "leapfrogging" between stages with an underlying sequential order.

Internet hosts per capita

The number of Internet hosts has been adopted as a measure of the Internet penetration of a country and the degree of national "connectivity". As mentioned by ITU,[66] "Internet hosts refer to the number of computers directly connected to the worldwide Internet network. Note that Internet host computers are identified by a two-digit country code or a three-digit code generally reflecting the nature of the organization using the Internet computer. The number of hosts is assigned to economies based on the country code although this does not necessarily indicate that the host is actually physically located in the economy. In addition, *all other hosts for which there is no country code identification are assigned to the United States.* Therefore the number of Internet hosts shown for each country can only be considered an approximation. Data on Internet host computers are from Internet Software Consortium and RIPE (Réseaux IP Européens)".

An increasing number of Internet hosts implies increased ability to handle, service and store large amounts of data.

Cross-country regression work has mainly used this variable as the most representative variable of Internet diffusion, for example Hargittai (1999), Kiiski and Pohjola (2001), and Robinson and Crenshaw (1999).

PCs per capita

Telephone lines and *personal computers* are key components for Internet access before 3G 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 and Coleman (2001) use the number of computer imports as a measure of "computer technology adoption".

PC estimates are available for developed countries, but measurement may be unreliable. 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, the use made of them or by which access method (e.g. shared Internet access, with multiple users for single PC).

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 as well as the number of payphones (data from telecom authorities or

[66] http://www.itu.int/ITU-D/ict/statistics/WTI_2003.pdf .

operators). Increased availability of telephone mainlines should increase Internet connectivity, assuming that 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 also important to be aware of the proxy variables that may be implicit in this measure. Telephone networks typically require large investments, and so average national income and the public resources available play a significant 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; Nepal and Cambodia, to take two examples, have geographically limited mainline networks, Turkey is an example of a country whose mainline network is widely distributed.

Mobile subscribers per capita

Mobile connectivity and this measure will become increasingly important in the future. Current methods of Internet access emphasize PC-based applications, with 3G and WAP less widely adopted. Inclusion of mobiles allows leapfrogging in, for example, Cambodia (ITU case study, 2002) to be counted. However, the 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 that are important now and will remain so in the future.

Access

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/organizational skills and knowledge transfer)". This introduces a broader definition of access and the factors determining use of ICTs, beyond narrowly defined connectivity.

Number of Internet users

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

Inhabitants > awareness > ICT access > users > subscribers

The number of *subscribers* paying for Internet access is more precise than the number of users and implies a certain degree of usage in terms of realized 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, thus reducing their comparability. For consistency, UNCTAD used ITU estimates of Internet users, weighted by population to yield Internet users per capita. The estimates in ITU surveys are consistently lower than those in SangoNet surveys (Nua). However, to test how representative ITU estimates are, countries were ranked and compared using Nua and ITU user estimates. Comparison of rankings revealed similar country profiles across both sources so, irrespective of actual indicator values, we can have confidence in the country rankings.

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 and Crenshaw, 1999). 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 per cent of online users and 68.4 per cent web content use English, down from the 80 per cent of English language web pages 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 realized as the proportion of Internet users. “Depth” measures of human capital, such as tertiary education, are considered less relevant for basic Internet access. We therefore included basic literacy in our index as an important determinant of access.

Cost of a local call

Prices are an important measure and determinant of access, as 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 and Technology, 2002). Some countries may have high Internet connectivity (e.g. high telephone and PC penetration) but relatively low user levels. The most widely used Internet access method is dial-up (U.S. Internet Council, 2000), with the following main charges:

1. Telephone charges (line rental and/or call charges paid to the PTO);

2. Internet access charges (paid to the ISP).

Internet pricing comparisons are complex (depending upon method of access, time and frequency of use), change rapidly and are often available only for developed countries.

Given data constraints for developing countries, we adopted the cost of a local call as the most representative indicator of cost of access. However, telephone charges issues include the following:

- Local call charges: some telephone operators do not charge directly for local calls (including operators in North America and New Zealand). This has been considered an integral factor 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 or the day of week, or whether the call is for Internet access; and
- Operators may provide discounted calls to user-specified numbers.

The reduced cost of calls should facilitate the expansion of access to ICTs.

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".

Appendix 3. Data sources

- Internet hosts, personal computers, cellular mobile telephone subscribers, main telephone lines in operation, number of estimated users, cost of local calls: ITU, 2006.
- Gross Domestic Product and Population: World Bank, World Development Indicator Online 2006.
- Adult Literacy rate: UNESCO, Institute for Statistics.

6. ANNEX TABLES

Annex table 1. 2004 Index of ICT diffusion by rank

Rank	Country	access index	connectivity index	ICT diffusion index
1	Luxembourg	0.928	0.703	0.815
2	United States	0.833	0.754	0.794
3	Iceland	0.854	0.706	0.780
4	Sweden	0.836	0.700	0.768
5	Denmark	0.828	0.667	0.748
6	Netherlands	0.803	0.642	0.723
7	Switzerland	0.764	0.645	0.705
8	Bermuda	0.777	0.625	0.701
9	Australia	0.807	0.589	0.698
10	United Kingdom	0.804	0.557	0.680
11	Finland	0.799	0.546	0.672
12	Hong Kong	0.741	0.602	0.672
13	Canada	0.804	0.514	0.659
14	Norway	0.758	0.558	0.658
15	New Zealand	0.832	0.478	0.655
16	Singapore	0.748	0.560	0.654
17	Israel	0.719	0.577	0.648
18	Germany	0.753	0.538	0.646
19	Korea (Rep. of)	0.773	0.506	0.639
20	Estonia	0.704	0.567	0.635
21	Austria	0.760	0.510	0.635
22	Japan	0.785	0.478	0.632
23	Ireland	0.727	0.496	0.611
24	Italy	0.753	0.452	0.602
25	France	0.730	0.464	0.597
26	San Marino	0.544	0.609	0.581
27	Malta	0.764	0.394	0.579
28	Belgium	0.735	0.421	0.578
29	Slovenia	0.719	0.406	0.562
30	Czech Republic	0.712	0.397	0.555
31	Spain	0.697	0.402	0.549
32	Cyprus	0.685	0.407	0.546
33	Barbados	0.725	0.334	0.529
34	Portugal	0.659	0.393	0.526
35	Macau	0.647	0.380	0.514
36	Antigua and Barbuda	0.585	0.400	0.506
37	Slovak Republic	0.678	0.321	0.499
38	Puerto Rico	0.644	0.302	0.498
39	Hungary	0.640	0.349	0.494
40	Greece	0.607	0.380	0.493
41	Qatar	0.733	0.312	0.492
42	New Caledonia	0.666	0.241	0.484
43	Lithuania	0.630	0.329	0.479
44	Latvia	0.649	0.289	0.469
45	Croatia	0.627	0.299	0.463
46	Bahrain	0.597	0.305	0.451
47	United Arab Emirates	0.609	0.291	0.450
48	French Polynesia	0.664	0.232	0.448

Rank	Country	access index	connectivity index	ICT diffusion index
49	Poland	0.616	0.272	0.444
50	Saint Lucia	0.603	0.265	0.434
51	Seychelles	0.609	0.252	0.430
52	Bulgaria	0.607	0.248	0.428
53	Kuwait	0.587	0.266	0.427
54	Saint Kitts and Nevis	0.601	0.250	0.426
55	Malaysia	0.622	0.229	0.425
56	Chile	0.612	0.233	0.423
57	Jamaica	0.598	0.243	0.421
58	Dominica	0.580	0.246	0.413
59	Brunei Darussalam	0.701	0.187	0.407
60	Serbia and Montenegro	0.699	0.182	0.403
61	Costa Rica	0.593	0.205	0.399
62	Mauritius	0.541	0.246	0.393
63	Russian Federation	0.566	0.219	0.392
64	Belarus	0.571	0.152	0.391
65	Trinidad and Tobago	0.574	0.206	0.390
66	Romania	0.582	0.184	0.383
67	Grenada	0.544	0.221	0.383
68	Uruguay	0.589	0.174	0.382
69	Suriname	0.648	0.167	0.373
70	Bosnia and Herzegovina	0.525	0.172	0.373
71	Argentina	0.576	0.168	0.372
72	Maldives	0.679	0.133	0.367
73	Turkey	0.535	0.193	0.364
74	Saudi Arabia	0.509	0.219	0.364
75	St. Vincent and the Grenadines	0.530	0.184	0.357
76	Brazil	0.532	0.180	0.356
77	Mexico	0.546	0.161	0.353
78	Kazakhstan	0.531	0.113	0.352
79	F.Y.R. Macedonia	0.534	0.169	0.352
80	Dominican Rep.	0.517	0.125	0.349
81	Ukraine	0.543	0.141	0.342
82	Thailand	0.541	0.142	0.341
83	Lebanon	0.532	0.128	0.330
84	South Africa	0.512	0.145	0.328
85	Colombia	0.531	0.124	0.328
86	Guyana	0.567	0.087	0.327
87	Venezuela	0.526	0.127	0.326
88	Belize	0.496	0.156	0.326
89	Tonga	0.530	0.123	0.326
90	China	0.513	0.133	0.323
91	Panama	0.530	0.103	0.316
92	Moldova	0.522	0.105	0.314
93	Jordan	0.518	0.106	0.312
94	Ecuador	0.500	0.122	0.311
95	Albania	0.519	0.101	0.310
96	Marshall Islands	0.657	0.048	0.309
97	Philippines	0.509	0.107	0.308
98	Armenia	0.526	0.087	0.306
99	Uzbekistan	0.512	0.031	0.306
100	Azerbaijan	0.524	0.082	0.303
101	Georgia	0.516	0.085	0.301

Rank	Country	access index	connectivity index	ICT diffusion index
102	Tunisia	0.477	0.122	0.300
103	Fiji	0.521	0.078	0.299
104	Peru	0.518	0.080	0.299
105	Mongolia	0.522	0.076	0.299
106	Cuba	0.660	0.027	0.298
107	Oman	0.501	0.093	0.297
108	El Salvador	0.485	0.109	0.297
109	Paraguay	0.499	0.092	0.295
110	Tajikistan	0.501	0.016	0.293
111	Botswana	0.481	0.100	0.291
112	Libya	0.611	0.050	0.290
113	Samoa	0.525	0.056	0.290
114	Iran (Islamic Rep. of)	0.462	0.106	0.284
115	Namibia	0.490	0.077	0.283
116	Cape Verde	0.465	0.101	0.283
117	Equatorial Guinea	0.529	0.031	0.280
118	Kyrgyzstan	0.516	0.039	0.278
119	Syria	0.476	0.078	0.277
120	Lesotho	0.460	0.032	0.277
121	Viet Nam	0.501	0.051	0.276
122	Bolivia	0.480	0.068	0.274
123	Myanmar	0.627	0.004	0.271
124	Indonesia	0.496	0.044	0.270
125	Sri Lanka	0.489	0.046	0.267
126	Zimbabwe	0.497	0.034	0.265
127	Guatemala	0.442	0.083	0.263
128	Gabon	0.425	0.091	0.258
129	Swaziland	0.466	0.043	0.255
130	Honduras	0.460	0.040	0.250
131	Nicaragua	0.450	0.048	0.249
132	Algeria	0.443	0.053	0.248
133	Morocco	0.407	0.083	0.245
134	Egypt	0.402	0.070	0.236
135	Vanuatu	0.444	0.023	0.233
136	Kenya	0.440	0.022	0.231
137	Rwanda	0.400	0.005	0.231
138	Haiti	0.384	0.019	0.227
139	Cameroon	0.416	0.023	0.220
140	Cambodia	0.431	0.008	0.220
141	Djibouti	0.417	0.019	0.218
142	India	0.407	0.023	0.215
143	Angola	0.414	0.016	0.215
144	Nigeria	0.410	0.018	0.214
145	Lao P.D.R.	0.416	0.011	0.214
146	Tanzania	0.415	0.012	0.213
147	Uganda	0.416	0.010	0.213
148	Zambia	0.415	0.010	0.213
149	Madagascar	0.418	0.006	0.212
150	Sudan	0.397	0.019	0.208
151	Papua New Guinea	0.393	0.021	0.207
152	Mauritania	0.367	0.044	0.205
153	Malawi	0.398	0.006	0.202
154	Togo	0.382	0.021	0.202

Rank	Country	access index	connectivity index	ICT diffusion index
155	Ghana	0.380	0.021	0.201
156	Bhutan	0.449	0.008	0.197
157	Guinea-Bissau	0.341	0.003	0.196
158	Eritrea	0.386	0.004	0.195
159	Somalia	0.435	0.014	0.195
160	Comoros	0.381	0.007	0.194
161	Burundi	0.383	0.003	0.193
162	Côte d'Ivoire	0.359	0.027	0.193
163	Yemen	0.357	0.025	0.191
164	Gambia	0.343	0.037	0.190
165	Pakistan	0.362	0.016	0.189
166	Senegal	0.344	0.033	0.188
167	Nepal	0.358	0.006	0.182
168	Mozambique	0.350	0.010	0.180
169	Central African Rep.	0.354	0.004	0.179
170	Sierra Leone	0.299	0.007	0.174
171	Bangladesh	0.336	0.010	0.173
172	Guinea	0.339	0.005	0.172
173	Ethiopia	0.333	0.002	0.168
174	Benin	0.315	0.010	0.163
175	Solomon Islands	0.341	0.016	0.155
176	Chad	0.294	0.003	0.149
177	Mali	0.270	0.010	0.140
178	Burkina Faso	0.253	0.008	0.130
179	Democratic Rep. of Congo	0.273	0.022	0.130
180	Niger	0.255	0.002	0.129

Annex table 2: ICT diffusion rankings 1997-2004

Country name	1997	1998	1999	2000	2001	2002	2003	2004
Albania	105	106	106	108	102	95	92	95
Algeria	127	129	127	127	134	133	132	132
Angola	143	151	144	148	147	148	148	143
Antigua and Barbuda	36	38	36	36	40	38	38	36
Argentina	59	61	62	62	59	67	70	71
Armenia	109	111	113	119	109	110	109	98
Australia	13	12	15	16	10	9	8	9
Austria	20	18	17	17	14	17	18	21
Azerbaijan	117	142	140	139	103	104	104	100
Bahrain	44	44	42	44	44	43	47	46
Bangladesh	164	164	164	163	171	171	171	171
Barbados	40	41	40	41	47	44	36	33
Belarus	48	50	50	54	61	60	59	64
Belgium	25	26	26	25	23	25	25	28
Belize	104	104	99	94	87	89	94	88
Benin	172	172	172	171	174	174	174	174
Bermuda	6	8	12	19	12	10	7	8
Bhutan	148	146	143	142	153	152	152	156
Bolivia	124	123	124	125	120	120	119	122
Bosnia and Herzegovina	68	69	68	65	66	65	69	70
Botswana	116	115	104	99	101	102	111	111
Brazil	93	87	75	72	75	77	79	76
Brunei Darussalam	33	36	37	39	43	50	55	59
Bulgaria	55	59	60	60	58	57	56	52
Burkina Faso	176	176	177	177	179	178	178	178
Burundi	150	149	148	144	158	160	160	161
Cambodia	137	136	131	131	138	138	139	140
Cameroon	140	140	138	137	140	141	141	139
Canada	9	9	10	11	13	15	15	13
Cape Verde	123	122	118	113	114	112	116	116
Central African Rep.	180	180	180	180	167	168	169	169
Chad	175	175	176	175	176	176	176	176
Chile	74	65	61	53	48	53	52	56
China	111	108	103	98	99	94	90	90
Colombia	73	75	80	83	89	88	89	85
Comoros	167	168	167	166	157	159	158	160
Democratic Rep. of Congo	174	174	174	173	180	180	180	179
Costa Rica	61	60	59	61	62	56	57	61
Côte d'Ivoire	166	159	158	155	161	161	161	162
Croatia	46	46	48	45	42	41	42	45
Cuba	96	94	101	106	94	97	99	106
Cyprus	23	25	27	28	30	28	29	32
Czech Republic	41	39	41	38	32	31	31	30
Denmark	7	6	7	8	6	5	5	5
Djibouti	156	157	162	165	141	140	140	141
Dominica	72	71	79	75	67	66	63	58
Dominican Rep.	76	77	74	74	69	75	78	80
Ecuador	99	101	97	107	110	107	105	94
Egypt	135	134	135	132	137	135	134	134
El Salvador	121	120	115	115	117	116	113	108
Equatorial Guinea	125	124	119	116	111	113	117	117

Country name	1997	1998	1999	2000	2001	2002	2003	2004
Eritrea	147	147	145	143	156	157	159	158
Estonia	35	32	33	31	33	33	28	20
Ethiopia	162	165	163	162	172	172	172	173
Fiji	100	98	98	97	96	96	97	103
Finland	3	4	6	10	8	7	10	11
France	22	23	24	26	25	24	23	25
French Polynesia	52	54	57	58	41	42	46	48
Gabon	141	143	149	157	131	130	131	128
Gambia	178	177	179	179	165	165	164	164
Georgia	89	92	90	100	104	103	98	101
Germany	21	21	21	18	20	18	17	18
Ghana	159	156	156	150	159	158	156	155
Greece	34	34	32	32	34	35	39	40
Grenada	51	52	52	51	65	64	58	67
Guatemala	134	131	132	130	129	128	128	127
Guinea	171	170	170	170	173	173	173	172
Guinea-Bissau	165	167	168	168	155	156	157	157
Guyana	86	89	88	80	85	86	87	86
Haiti	130	130	129	129	139	139	138	138
Honduras	129	128	128	128	128	129	129	130
Hong Kong (China)	10	13	11	12	11	12	11	12
Hungary	45	43	44	42	39	39	37	39
Iceland	4	3	2	3	2	3	3	3
India	136	135	136	136	148	146	146	142
Indonesia	120	117	120	121	123	125	125	124
Iran (Islamic Rep. of)	107	110	111	109	115	111	103	114
Ireland	24	22	23	23	21	21	19	23
Israel	18	20	22	22	24	26	26	17
Italy	26	24	25	24	26	23	24	24
Jamaica	91	88	89	84	83	62	60	57
Japan	15	17	19	21	22	22	20	22
Jordan	103	100	100	96	93	92	95	93
Kazakhstan	60	63	64	66	76	79	81	78
Kenya	133	133	134	135	135	137	136	136
Korea (Rep. of)	27	27	18	15	17	16	16	19
Kuwait	43	45	45	49	55	55	53	53
Kyrgyzstan	112	113	114	117	116	117	118	118
Lao P.D.R.	131	132	133	133	143	142	142	145
Latvia	54	49	55	56	51	51	41	44
Lebanon	63	67	66	71	78	80	82	83
Lesotho	106	107	107	110	119	119	121	120
Libya	94	91	92	95	108	106	110	112
Lithuania	49	48	53	55	54	52	49	43
Luxembourg	8	7	8	5	3	2	2	1
Macao (China)	30	29	31	34	35	34	34	35
Madagascar	144	144	141	147	142	143	143	149
Malawi	142	138	155	151	151	153	154	153
Malaysia	53	51	46	46	50	54	54	55
Maldives	80	80	82	77	73	72	72	72
Mali	177	178	175	174	177	177	177	177
Malta	38	37	38	35	29	29	30	27
Marshall Islands	70	72	70	73	88	91	93	96
Mauritania	163	162	160	160	160	155	155	152

Country name	1997	1998	1999	2000	2001	2002	2003	2004
Mauritius	69	64	65	63	64	63	67	62
Mexico	101	97	95	92	72	73	77	77
Moldova	92	90	93	90	100	98	91	92
Mongolia	108	109	108	102	112	114	106	105
Morocco	154	153	154	149	136	136	137	133
Mozambique	161	166	166	167	169	169	168	168
Myanmar	88	93	94	101	118	118	120	123
Namibia	113	114	116	111	113	115	114	115
Nepal	153	154	150	152	166	166	166	167
Netherlands	17	11	9	7	7	8	9	6
New Caledonia	50	55	56	57	37	37	40	42
New Zealand	11	15	14	14	19	19	21	15
Nicaragua	126	127	130	134	130	131	130	131
Niger	179	179	178	178	178	179	179	180
Nigeria	151	150	152	156	150	149	149	144
Norway	1	2	4	6	9	13	14	14
Oman	102	103	110	112	98	100	100	107
Pakistan	152	152	153	154	163	163	165	165
Panama	95	95	91	91	84	87	88	91
Papua New Guinea	170	173	173	176	149	150	150	151
Paraguay	110	105	109	105	97	99	102	109
Peru	114	112	112	114	107	108	108	104
Philippines	97	99	96	93	106	105	101	97
Poland	57	53	51	52	53	48	48	49
Portugal	29	28	28	30	31	32	33	34
Puerto Rico	32	33	35	37	36	36	35	38
Qatar	39	40	39	40	49	49	44	41
Romania	77	84	87	89	77	70	68	66
Russian Federation	66	70	69	69	79	76	71	63
Rwanda	138	137	139	138	133	134	135	137
Saint Kitts and Nevis	42	42	43	43	52	47	50	54
Saint Lucia	85	86	86	78	71	68	64	50
Samoa	98	102	105	103	105	109	112	113
San Marino	12	10	3	2	18	20	22	26
Saudi Arabia	84	85	85	88	86	82	76	74
Senegal	169	169	169	169	168	167	167	166
Seychelles	58	57	49	48	46	46	51	51
Sierra Leone	168	163	161	161	170	170	170	170
Singapore	16	16	16	13	16	11	13	16
Slovak Republic	47	47	47	47	45	45	45	37
Slovenia	28	30	29	27	27	27	27	29
Solomon Islands	173	171	171	172	175	175	175	175
Somalia	157	161	165	164	162	162	162	159
South Africa	79	76	76	85	82	83	84	84
Spain	31	31	30	29	28	30	32	31
Sri Lanka	118	118	122	122	122	124	124	125
St. Vincent and the Grenadines	81	82	84	86	74	81	62	75
Sudan	145	145	142	141	154	154	151	150
Suriname	65	66	72	67	70	74	73	69
Swaziland	132	125	125	126	127	127	127	129
Sweden	5	5	5	4	4	4	4	4
Switzerland	14	14	13	9	5	6	6	7
Syria	115	116	117	118	124	123	122	119

Country name	1997	1998	1999	2000	2001	2002	2003	2004
T.F.Y.R. Macedonia	67	68	67	68	80	78	74	79
Tajikistan	75	78	83	82	95	101	107	110
Tanzania	149	148	147	146	145	144	145	146
Thailand	90	96	102	104	91	84	80	82
Togo	160	160	159	159	152	151	153	154
Tonga	87	81	78	81	63	69	83	89
Trinidad and Tobago	64	62	63	59	60	61	65	65
Tunisia	122	121	121	120	121	121	115	102
Turkey	78	74	71	70	68	71	75	73
Uganda	158	158	157	158	144	145	144	147
Ukraine	82	83	81	79	90	90	85	81
United Arab Emirates	37	35	34	33	38	40	43	47
United Kingdom	19	19	20	20	15	14	12	10
United States	2	1	1	1	1	1	1	2
Uruguay	62	56	58	64	56	59	66	68
Uzbekistan	71	73	73	76	92	93	96	99
Vanuatu	139	139	146	145	132	132	133	135
Venezuela	83	79	77	87	81	85	86	87
Viet Nam	128	126	126	123	125	126	126	121
Yemen	155	155	151	153	164	164	163	163
Serbia and Montenegro	56	58	54	50	57	58	61	60
Zambia	146	141	137	140	146	147	147	148
Zimbabwe	119	119	123	124	126	122	123	126

REFERENCES

Publications

Acemoglu, D., Johnson, S., and Robinson, J. (2001), "An African Success Story: Botswana", *working paper*, July, available at http://econ-www.mit.edu/faculty/download_pdf.php?id=610

Acemoglu, D., Johnson, S., and Robinson, J. (2003), "An African Success Story: Botswana", published in *In Search of Prosperity: Analytic Narratives on Economic Growth*, Dani Rodrik ed., Princeton University Press, pp. 80-122, April 14.

Annamalai, K., and Rao, S. (2003), "ICT's E-choupal and Profitable Rural Transformation", *World Resources Institute*, August, available at http://www.digitaldividend.org/pdf/echoupal_case.pdf.

Barboza, D. and Altman, D. (2005), "That Blur? It's China, Moving Up in the Pack", *The New York Times*, December 21, available at http://select.nytimes.com/gst/abstract.html?res=F50B1EFC3F540C728EDDAB0994DD404482

Becker, G. (1997), "Latin America Owes a Lot to Its Chicago Boys", *Business Week*, June 9, reprinted in Hoover Digest No. 4, Hoover Institution, 1997, available at http://home.uchicago.edu/~gbecker/Businessweek/BW/1997/06_09_1997.pdf

Bridges.org (2001), "Comparison of E-Readiness Assessment Models" available at http://www.bridges.org/ereadiness/report.html.

Caselli, F. and W.J. Coleman (2001), "Cross-country technology diffusion: the case of computers", *NBER Working Paper* No. 8130, Cambridge, MA: NBER, available at http://papers.nber.org/papers/w8130.pdf

Edgeworth, F.Y. (1925), "The Plurality of Index Numbers", Economic Journal.

Fisher (1922), “The Making of Index Numbers” quoted in R.G.D. Allen, *Statistics for Economists*, 8th edition, 1957 Hutchinson & Co.

G8 (2005), Chair's Summary, Gleneagles Summit, 6-8 July 2005, available at http://www.g8.gov.uk/servlet/Front?pagename=OpenMarket/Xcelerate/ShowPage&c=Page&cid=1119518698846.

GIT (2000), High Tech Indicators and associated articles, Georgia Institute of Technology, available at http://www.gatech.edu.

Gillwald, A. (2005), "*Towards an African e-Index*", The LINK Centre, Wits University School of Public and Development Management, Johannesburg, available at http://link.wits.ac.za/research/e-index.html.

Hargittai, E. (1999), "Weaving the Western Web: Explaining Differences in Internet Connectivity Among OECD Countries", *Telecommunications Policy*, 23, 701–718, available at http://www.elsevier.com/wps/find/journaldescription.cwshome/30471/description#description

Hundt, R. (2005), "Limits on wireless leave U.S. at risk", *San Jose Mercury News*, Oct. 16, available at http://www.mercurynews.com/mld/mercurynews/news/opinion/2917284.htm.

Isenberg, D. (1998), "The Dawn of the Stupid Network", *netWorker* (2.1), February/March, pp. 24-31; available at http://www.isen.com/papers/Dawnstupid.html

Jensen, M. (2000), "The Internet in Africa", 2000 Conference of the International Federation for Information Processing WG9.4 mimeo, "Social Implications of Computers in Developing Countries".

Jhunjhunwala, A., Narasimhan, S. and Ramachandran, A. (2005), "Case Study: India, Enabling Rural India with Information and Communication Technology Initiatives, Building Digital Bridges", 365-419, International Telecommunication Union, Geneva, Publication 378-05, ISBN 92-61-11321-4, November 2005, available at http://www.itu.int/dms_pub/itu-s/opb/pol/S-PN-378-05-PDF-E.pdf.

Kedzie, C. (1997), "Communication and Democracy: Coincident Revolutions and the Emergent Dictator's Dilemma", RGSD-127, RAND Corporation, Santa Monica CA.

Kendrick, B. (2006), "The $200 Billion Broadband Scandal, Teletruth," available at http://www.newnetworks.com/broadbandscandals.htm.

Kennard, W. (2000), "Internet Telephony: America Is Waiting", Voice Over Net Conference, September 12, 2000, available at http://www.fcc.gov/Speeches/Kennard/2000/spwek019.html.

Kiiski, S. and Pohjola, M. (2001), "Cross-country diffusion of the Internet", available at http://www.wider.unu.edu/publications/dps/DP2001-11.pdf.

Kushnick, B. (2006), "The $200 Billion Broadband Scandal", *Teletruth*, available at http://www.newnetworks.com/broadbandscandals.htm

Le, H. (2005), "Vietnam medic makes DIY endoscope, BBC Go Digital", http://news.bbc.co.uk/1/hi/technology/4145984.stm.

Mahanta, V. (2001). "How To Survive the ISP Shakeout," *Business Today*, 23 December 2001, available at http://www.hclinfinet.com/pr.html.

McConnell International (2000), "Risk E-Business: Seizing the Opportunity of Global E-Readiness", subsequently updated: "Ready? Net. Go! Partnerships Leading the Global Economy" (2001), available at http://www.mcconnell international.com.

Minges, M., Ismael, M. and Press, L. (2001), "The e-City, Singapore Internet Case Study", International Telecommunication Union, Geneva, August 2001, available at http://www.itu.int/ITU-D/ict/cs/singapore/singapore.html.

Minges, M. (2005) "Measuring Digital Opportunity", ITU Workshop on WSIS Thematic Meeting on Multi-Stakeholder Partnerships for Bridging the Digital Divide, Seoul (Rep. of Korea), 23-24 June 2005, *Document BDB WSIS/06, ITU*. available at http://www.itu.int/osg/spu/statistics/DOI/linkeddocs/Measuring_Digital_Opp_Revisd_23_Nov_2005%20(2).pdf

Mosaic Group (1998), "An Internet Diffusion Framework", Communications of the ACM, October, 41(10), 21-26, available at http://som.csudh.edu/fac/lpress/articles/acmfwk/acmfrwk.htm

Mosaic Group (1996), "The Information Technology Capability of Nations: A Framework for Analysis", available at http://mosaic.unomaha.edu/gdi.htm.

Nua Internet Surveys (2001), "How Many Online?" available at http://www.nua.ie/surveys

Nua Internet Surveys (2000), "Methodology", available at http://www.nua.ie/surveys

Pangestu, M. (2002), "Industrial Policy and Developing Countries, in Development, Trade and the WTO, A Handbook", World Bank, 2002.

Paul, J. (2004), "n-Logue's Rural Connectivity Model", World Resources Institute, December 2004, available at http://www.digitaldividend.org/pdf/nlogue.pdf.

Porter, M. E. and Stern, S. (1999), "The New Challenge to America's Prosperity: Findings from the Innovation Index", Washington, DC: Council on Competitiveness, available at http://www.compete.org/pdf/index.pdf.

Press, L. (1995), "Developing Networks in Less Industrialized Nations", *IEEE Computer*, 28(6), June, 66-71.

Press, L. (1996-a), "The Role of Computers Networks in Developing Nations", *Communications of the ACM*, 39(2), February, 23-29.

Press, L. (1996-b), "Seeding Networks: the Federal Role", *Communications of the ACM*, 39(10), October, 11-18, available at http://som.csudh.edu/fac/lpress/articles/govt.htm.

Press, L. (1997), "What May the WTO Telecommunication Agreement Mean for Emerging Nations?" *OnTheInternet*, 3(3), May/June, 36-38, available at http://localhost/som/articles/wto.htm.

Press, L. (1999), "A Client-Centered Networking Project in Rural India", *OnTheInternet*, January/February, 36-38 available at http://som.csudh.edu/fac/lpress/devnat/nations/india/pondyoti.htm.

Press, L., Burkhart, G., Foster, W., and Goodman, S. (1999), "The Internet in India and China", INET '99, San Jose, CA, June, available at http://www.isoc.org/ isoc/conferences/inet/99/proceedings/3a/3a_3.htm

Press, L., Foster, W., Wolcott, P. and McHenry, W. (2003), "The Internet in India and China," *The Journal of Information Technologies and International Development*, MIT Press, 1(1), Fall 2003, 41-60, available at http://mitpress.mit.edu/journals/pdf/itid_1_1_41_0.pdf

Press, L. (2003), "Wireless Internet Connectivity for Developing Nations", *First Monday*, 8(9), September, available at http://www.firstmonday.org/issues/issue8_9/press/index.html.

Press, L. (2004-a), "The Internet in Developing Nations: Grand Challenges", *First Monday*, 9(4), April, available at http://www.firstmonday.org/issues/issue9_4/press/.

Press, L. (2004-b), "Refuting Objections to a Global Rural Network (GRNet) for Developing Nations", *First Monday*, 9(8), August, available at http://www.firstmonday.org/issues/issue9_8/press/.

Qiang, X., and Beach, S. (2002) "The Great Firewall of China," Los Angeles Times 25 August, available at http://www.cpj.org/news/2002/China_Firewall 25aug02.html.

Rajashekhar, V.V. (2005), "e-Chaupal", Proceedings of the Asia-Pacific Telecommunity Seminar on Leveraging Private Investment for Rural ICT Development, 5-7, July, Chiang Rai (Thailand), available at http://www.aptsec.org/meetings/2005/ICT-WB/docs/PROCEEDINGS.doc

Reed, S. (2005), "Privatization of Latin American Telecommunications Firms", Fabian Ponce O & Asociados C Ltda., Quito (Ecuador), available at http://www.lectlaw.com/filesh/il-2.htm.

Robinson, K.K., and Crenshaw, E.M. (1999), "Cyber-Space and Post-Industrial Transformations: A Cross-National Analysis of Internet Development", *Working Paper*, Department of Sociology, Ohio State University, December.

Rodriguez F. and Wilson, E. (2000), "Are Poor Countries Losing the Information Revolution?", *infoDev Working Paper*, Washington DC: World Bank, available at http://wbln0018.worldbank.org/ict/resources.nsf/a693f575e01ba5f385256b500062af05/45a738b8c7305beb85256da400504c12/$FILE/Wilson&Rodriguez.doc

Sadowsky, G. (1993), "Network Connectivity for Developing Countries", Communications of the ACM, August, 36, available at http://portal.acm.org/citation.cfm?id=163388&jmp=references&dl=GUIDE&dl=ACM.

Saltzer, J. H., Reed, D.P. and Clark, D.D. (1984), "End-to-end Arguments in System Design", Second International Conference on Distributed Computing Systems (April 1981) pages 509-512. Published with minor changes in ACM Transactions in Computer Systems 2, 4, November 1984, 277-288, available at http://web.mit.edu/Saltzer/www/publications/endtoend/endtoend.pdf

Schatz, A. (2006), "Net Firms Raise Capitol Hill Profile", *Wall Street Journal*, January 28, Page A4, available at http://online.wsj.com/article/SB113841720059659024-email.html.

Sprigman, C. and Lurie, P. (2004), "Broadband Marxism", *Foreign Policy*, March/April, available at http://www.networkideas.org/news/apr2004/news21_Broadband_Marxism.htm.

Swaminathan, M. S. (2001). "Antyodaya Pathway of Bridging the Digital Divide", Lecture delivered before the Tilak Smarak Trust, Pune (India), August 1st, available at http://www.worldbank.org/wbi/B-SPAN/docs/antyoday.pdf.

Tongia, R. (2005), "Reducing One Aspect of the Digital Divide — Connectivity (Introducing the FiberAfrica Proposal — a Leapfrog Open Access Network)", School of Computer Science (ISRI) Department of Engineering & Public Policy, Carnegie Mellon University, May 13, available at http://www.contrib.andrew.cmu.edu/~tongia/FiberAfrica--ending_a_digital_divide.pdf

Wellenius, B. (1997), "Extending Telecommunications Service to Rural Areas, The Chilean Experience", Note 105, February, World Bank, available at http://www1.worldbank.org/viewpoint/HTMLNotes/105/105welle.pdf

Wellenius, B. (2001), "Closing the Rural Communication Access Gap: Chile 1995-2002", 24 June, World Bank, available at http://rru.worldbank.org/Documents/PapersLinks/1222.pdf

WTO (1998), "Telecommunication Services", Background Note by the Secretariat, December 8, available at http://www.wto.org/english/tratop_e/serv_e/w74.doc

Reports

Balancing Act (2004), African ICT Infrastructure Investment Options, Balancing Act for UK's Department for International Development (DFID), available at http://www.afridigital.net/downloads/DFIDinfrastructurerep.pdf

Bandwidth Report (2006), January 23, available at http://www.websiteoptimization.com/bw/0601/

Center for Democracy and Technology (2002), Bridging the Digital Divide, available at http://www.cdt.org/international/ceeaccess.

Delgado, A. (2005), Estadísticas 2005, Minister of Education of Chile, May.

Grupo de Acción Digital (2004), Agenda Digital, available at http://hasp.axesnet.com/contenido/documentos/Agenda%20Digital%20-%20Chile%202004%20-202006.pdf.

Gwartney, J., Lawson, R. and Gartzke, E. (2005), Economic Freedom of the World: 2005 Annual Report, The Fraser Institute, Vancouver Canada, available at http://www.freetheworld.com.

Infocomm Development Authority of Singapore (2006), Full Competition in Telecommunications Sector, Singapore IDA, available at http://www.ida.gov.sg/ idaweb/pnr/infopage.jsp?infopagecategory=&infopageid=I489

ITU (2001-a), Effective Regulation Case Study: Botswana 2001, International Telecommunication Union, Geneva, available at http://www.itu.int/itudoc/gs/promo/ bdt/cast_reg/79121.html

ITU (2001-b), Counting the Net: Internet Access Indicators, available at http://www.isoc.org/isoc/conferences/inet/00/cdproceedings/8e/8e_1.htm.

ITU (2002), World Telecommunication Development Report 2002, International Telecommunication Union, available at http://www.itu.int/ITU-D/ict/publications/wtdr_02/index.html.

ITU (2003), World Telecommunication Development Report 2002, International Telecommunication Union, available at http://www.itu.int/ITU-D/ict/statistics/WTI_2003.pdf

Nascom (2005), Internet Users and Subscribers: 1998-2005, available at http://www.nasscom.org/images/internetecommerce-01.pdf

Open Net Initiative (2005), Internet Filtering in China in 2004-2005: A Country Study, available at http://www.opennetinitiative.net/studies/china/ONI_China_Country_ Study.pdf.

Point Topic (2005), Singapore Broadband Overview, 30 August, available at http://www.point-topic.com/content/operatorSource/profiles/Singapore.htm&comp_id=775&g=1

Point Topic (2005), World Broadband Statistics: Q3 2005, December, available at http://www.point-topic.com/contentDownload/dslanalysis/world%20broadband%20statistics%20q3%202005.pdf

Statoids database (2005), (queried January 2006), available at http://www.statoids.com/ucl.html.

SUBTEL (2004), Informe Final Monitoreo, December, available at http://www.infocentros.gob.cl/Descargables/INFORME_MONITOREO_04.pdf.

SUBTEL (2005), Informe Semestral Monitoreo, June, available at http://www.infocentros.gob.cl/Descargables/INFORME_MONITOREO_05.pdf.

TeleGeography (2000), Hubs and Spokes, A TeleGeography Internet Reader, Washington, DC: TeleGeography, Inc, book review available at http://www.vanbest.org/janpascal/publications/2000/ReviewHubsAndSpokes.htm

UNCTAD (2005), Information Economy Report 2005, available at http://www.unctad.org/Templates/WebFlyer.asp?intItemID=3591&lang=1

UNCTAD (2004), The Digital Divide: ICT Development Indices 2004, available at http://stdev.unctad.org

UNCTAD (2003), Information and Communication Technology Development Indices, available at http://stdev.unctad.org

United Nations (2004), UN Global E-Government Readiness Report 2004: Towards Access for Opportunity, United Nations Online Network in Public Administration and Finance, UNPAN/2004/11, Department of Economic and Social Affairs, New York, available at http://unpan1.un.org/intradoc/groups/public/documents/un/unpan 019207.pdf

UNDP (2001), Human Development Report, 2001: Making New Technologies Work for Human Development, UNDP, New York, available at http://hdr.undp.org/reports/global/2001/en/

UNDP (2004), Note on statistics in the Human Development Report, available at http://hdr.undp.org/reports/global/2004/pdf/hdr04_backmatter_2.pdf

UNDP (2005), Human Development Report, 2005, UNDP, New York, available at http://hdr.undp.org/reports/global/2005/

UNIDO (2002), Industrial Development Report, UNIDO, Vienna, June/July, available at http://www.unido.org/doc/24397

U.S. Internet Council (2000), “State of the Internet Report 2000”, available at http://www.usinternetcouncil.org.

World Bank (2006), World Development Indicators Database, queried January 2006.

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