Information and Communication Technologies and the Global Digital Divide

Technology Transfer, Development, and Least Developing Countries

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ABSTRACT This article examines the global digital divide and discusses conditions and circumstances that have contributed to its creation. An important issue this article explores is whether there is a convergence, absolute convergence, divergence, or relative divergence in the application and diffusion of Information and Communication Technologies (ICTs) between developed countries and Least Developed Countries (LDCs), and if so, which of these conditions will continue. A second issue addressed by this article involves the basic conditions required in a country to facilitate technology transfer, application, and diffusion of ICTs. This article draws on several highly respectable data sources and an extensive body of literature to provide a fairly clear picture of how the ICT revolution is shaping up globally. For a number of reasons, mostly related to data availability, data timeliness, and data accuracy, the article does not pretend to be a full assessment of the ICT global situation between countries.

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INTRODUCTION

Many parts of the world are undergoing a *digital revolution* in the area of Information and Communication Technologies (ICTs) (Commission of the European Communities, 2001). A recent United Nations Report (2000, p. 3) notes, "the world is undergoing a revolution in information and communication technologies that has momentous implications for the current and future social and economic situation of *all* countries of the world" (emphasis added). The report identifies several important benefits to countries and their populations from the wide application and use of ICTs, including:

1. Direct contribution of the ICT sector's output to the economy . . .;
2. improvement to public sector administration, in particular that transparency in the procurement process for public service contracts had reduced corruptive practices;
3. tremendous potential for improving education, including distance learning and training;
4. important improvements in the delivery of services such as health care, including . . . the application of tele-medicine; and
5. enabling countries to monitor ecological situations and maintain environmental stability (United Nations, 2000, pp. 4–5).

Further, Graham (2002, p. 34) writes that ICTs benefit large, advanced urban centers:

> ICTs allow specialist urban centers, with their high-value-added services and manufacturing, to extend their powers, markets and control over ever-more distant regional, national, international and even global hinterlands. ICTs support the accelerating and spiraling contacts, transactions, communications, flows and interactions that help to bind, integrate and add economic dynamism to the vast, extended and multi-centered urban settlements, corridors and regions of our age.

Moreover, Navas-Sabater, Dymond, and Junutumen (2002, p. 1) of the World Bank note that ICTs impact poverty reduction in the following ways:

> ICTs promote integration of isolated communities into the global economy.
>
> ICTs promote productivity gains, efficiency and growth.
>
> ICTs improve the delivery of public services.

ICTs and technology transfer can benefit and move a country ahead in economic, human capital, and social development (see Sahay & Avgerou, 2002; United Nations Development Programme, 2001). Technology is the latest "knowledge, skills and practices involved in the production, consumption and distribution of goods and services in an economic development process" (Eggleston, Jensen, & Zeckhauser, 2002; Wangwacharakul, n.d.). Technology in itself is not inherently good or bad; the outcome results from how it is used (United Nations Development Programme, 2001). *Technology transfer* is the communication, use, and application of the latest knowledge, skills, and practices for mitigating and adapting to change, and it covers the processes of transfer in and between developed countries, developing countries, and transition economies (United Nations Industrial Development Organization, 2002; Wangwacharakul, n.d.).

However, not every large urban center or country is participating in the digital revolution and modern technology, or keeping up with the constantly changing ICTs. ICT transfer and adaptation has been slow in finding its way into many Least Developing Countries (LDCs). At the same time, some LDCs that are transforming to transition economies are surging ahead in ICT application and use; other non-transition or slower-transition LDCs are not. Examples of transition economies include Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyz Republic, Moldova, Russia, Uzbekistan (Commonwealth of Independent States); the Czech Republic, Estonia, Hungary, Poland, Slovenia (recent applicants to the European Union); Lithuania, the Slovak Republic (Central Europe and the Baltics); Albania, Bulgaria, Croatia, and Romania (Southeastern Europe) (see Clarke, 2001). A large number of non- or slower-transition economies are located in sub-Saharan Africa and parts of Asia (South Asia).

The marked gap between the number of countries that are high-level ICT participants and the number that are low-level ICT participants has been referred to as the *global digital divide* (World Economic Forum, 2000). Put another way, there is a starkly uneven speed and pattern or gap of ICT diffusion between industrialized countries and LDCs as measured by the number of phone lines per inhabitants (*teledensity*), the number of Internet hosts, the number of Internet users, the number of households that own computers, and the number of cell and mobile phone users (Campbell, 2001). The global digital divide, as well as the digital divide within countries, is also referred to as the *technological divide*, the *racial digital divide*, and the *lack of digital inclusion* (Rice, 2001).

The lack of the application and diffusion of ICTs in LDCs is exacerbated by the fact that more than 80% of all web sites are in English, a language understood by only about 10% of the world's population (BBC News

Online, 1999a; Organization for Economic Cooperation and Development [OECD], 2001) including a very, very small percentage of the world's poor. Further, minority languages are dramatically underrepresented on the World Wide Web (Kenny, 2002). Bolt and Crawford (2000) have described this condition as the *World White Web*. McNair (2000) notes that what has resulted from the use of ICTs is a global occurrence in which "the educated (information rich) become richer and the non- or less-educated (information poor) become poorer." Graham (2002, p. 36) argues that ICTs

> Extend the power of the powerful; underpin intensified unevenness through tying together international divisions of labour; allow socioeconomically affluent groups selectively to bypass the local scale; and be culturally and economically biased, especially in terms of the wider development of what we might term the emerging "international information marketplace."

Graham (2002, p. 37) continues: "thus, the uneven growth of the Internet and other ICT-mediated systems, represents a subtle, often invisible, but immensely powerful process of *dualization* within and between settlements" (emphasis added).

This article examines the global digital divide and discusses conditions and circumstances that have contributed to its creation. An important issue this article explores is whether there is a convergence, absolute convergence, divergence, or relative divergence in the application and diffusion of ICTs between developed countries and LDCs, and, if so, which of these conditions will continue. A second issue addressed by this article involves the basic conditions required in a country to facilitate technology transfer, application, and diffusion of ICTs. This article draws on several highly respectable data sources and an extensive body of literature to provide a fairly clear picture of how the ICT revolution is shaping up globally. For a number of reasons mostly related to data availability, data timeliness, and data accuracy, the article does not pretend to be a full assessment of the ICT global situation between countries.

THE IMPORTANCE OF ICTs IN A COUNTRY'S DEVELOPMENT

ICTs denote a wide range of services, applications, and technologies using various types of equipment and software. Modern ICT services include cellular and mobile telephones, fax, e-mail, transfer of files from one computer to another, and the use of the Internet. The OECD (2001) calls

these services *readiness indicators*. ICT applications include videoconferencing, teleworking, distance learning, management information systems, and stock taking. Simply put, ICTs are "the set of activities [and services] which facilitate by electronic means the processing, transmission and display of information" (Rodriguez & Wilson, 2000, p. 10). In a broader sense, ICTs include the use of television and the radio (Kenny, 2002; Rodriguez & Wilson, 2000). Both developed (industrialized) countries and some LDCs are benefiting from the rapid growth, development, and application of ICTs. According to the Commission of the European Communities (2001, p. 7),

> . . . ICTs are *already important* to the function of developing countries and emerging economies. . . . Large businesses and governments depend on their communications networks and computer applications to *function effectively* in terms of administration, analysis, and information dissemination, and to *reduce transaction costs*. . . . (italics added)

This observation suggests that ICTs are reshaping the flow of investments, goods, and services around the global economy. International businesses, local companies, and even governments see strong and highly developed ICT networks as requirements for investment growth and development (see Clarke, 2001). Succinctly stated, ICTs have "rocked the way we deliver and receive information and the way we do business" (BBC News Online, 1999b).

Table 1 shows three indicators of ICT use in selected industrialized countries as of September 2001. Norway and Sweden have the highest percentage of households with a fixed telephone line (100% telephone penetration rate). Sweden has the highest percentage of persons 16 years and older with Internet access at home and work (107%), followed by the United States (101%), Norway (100%), Australia (92%), and Ireland (78%). Sweden also has the highest percentage of persons 16 years and older with Internet access using the Internet (78%). However, as Table 2 indicates, the United States is ranked number one in the adoption and use of ICTs. Sweden, Australia, and Norway are ranked second, third, and fourth, respectively, of the 14 countries listed.

Stewart (1997, pp. x–xi, 6) notes that in a networked society, economic well-being is information and knowledge based. He says:

> Knowledge is more valuable and more powerful than natural resources, big factories, or fat bank rolls.
>
> Knowledge and information, not scientific knowledge, but news, advice,

Table 1

INDICATORS[1] OF ICT USE IN SELECTED INDUSTRIALIZED COUNTRIES (SEPTEMBER 2001)

Country	*Households with a fixed telephone line (%)*	*Persons 16 years and over with Internet access home/work[2] (%)*	*Persons 16 years and over with Internet access using the Internet (%)*
Australia	97	92	64
France	90	42	73
Germany	97	64	65
Ireland	84	78	46
Italy	93	54	60
Norway	100[3]	100	64
Sweden	100[3]	107[3]	78[3]
United Kingdom	94	77	43
United States	94	101	64

[1]This table presents three statistical indicators. The NOIA study used a total of 23 statistical indicators.
[2]Percentages of home access and work access added together.
[3]Leading country in this indicator.
Source: Derived from National Office for the Information Economy (Australia) (2002).

TABLE 2

NOIE (AUSTRALIA) SUMMARY RANKING OF COUNTRIES' ADOPTION AND USE OF ICTS (FROM HIGHEST TO LOWEST)

1. United States	8. South Korea
2. Sweden	9. Taiwan
3. Australia	10. United Kingdom
4. Norway	11. Germany
5. New Zealand	12. Ireland
6. Hong Kong	13. France
7. Singapore	14. Italy

Source: Derived from National Office for the Information Economy (Australia) (2002).

> entertainment, communication, service have become the economy's primary raw materials and its most important product.
>
> Knowledge has become the preeminent economic resource.

If Stewart is correct, it becomes an economic necessity for *all* of the global community to leverage the application and use of ICTs (emphasis added). Yet, all countries are not the same relative to governance, transparency, rule of law, property rights, economic structures, per capita income, education, health, and other factors. Countries that have a high level of adoption and diffusion of ICTs see significant levels of economic and social developments and interactions in their societies. As a result, ICTs have (and can) become indispensable tools for a country's immediate and long-term development, and ICTs contribute to a country's improvements in social policy areas such as poverty, health care, and education (United Nations Development Programme, 2000).

Considering the ways in which countries are different, Rodriguez and Wilson (2000, p. 23), through empirical analysis, conclude that there are two fundamental factors that separate highly technological countries from those that are not: "an economic environment conducive to investment, and a climate of civil liberties conducive to research and expansion of communications." Investment is difficult to have unless there is a focus on human capital development, a low level of unproductive government expenditures, security of property rights, a low level of expropriation risk, and basic political freedoms (see Barro, 1997). Human capital development is especially important in the areas of education and health because they have a synergistic relationship to higher levels of technological investment (see Rodriguez & Wilson, 2000). Political freedoms and other civil liberties, government transparency, and protection of property rights are central to technological transfer, diffusion, and innovation in a country. Minimum levels of government interference facilitate a market mechanism that allows the flow and exchange of goods, services, and information. The absence of these conditions within LDCs contribute to a *market efficiency gap*—"the difference between the level of service penetration that can be reached under current plans and conditions, and the level one would expect under optimal market conditions"—which in turn facilitates the *access gap* or the lack of affordability of ICTs (Navas-Sabater, Dymond, & Junutumen, 2002). LDCs, more often than not, tend to have governments that are politically volatile and unstable with uncompetitive industries and dysfunctional public bureaucracies (Sahay & Avgerou, 2002). From this perspective, the legal, political, and economic circumstances

under which a country operates gives some indication of a country's e-ready condition (InfoDev.org, 2002).

Therefore, under the right circumstances, ICTs can greatly expand a country's economic growth, create or enhance a country's participation in global markets, dramatically improve human welfare and human capital, and promote political accountability (United Nations Development Programme, 2000). According to Kenny (2002) of the World Bank, ICTs are "powerful tools for empowerment and income generation in LDCs." ICTs, then, have tremendous enabling potential for the individual, community, or country (especially a LDC). ICTs can be mobilized and shaped in ways that can help to make the effects on a country's human capital development more progressive and positive (Graham, 2002). Yet, because of ICTs' potential in promoting democratization and human capital development, a country can be ambivalent toward their widespread general application and use. Countries under authoritarian regimes recognize the power of ICTs, especially the Internet, to create political instability and change. As a result, authoritarian regimes shape the growth and diffusion of ICTs to their political advantage by exerting control and censorship over ICT use (see Kalathil, 2001; Kalathil & Boas, 2001).

APPLICATION AND USE OF ICTs BETWEEN DEVELOPED AND LEAST DEVELOPED COUNTRIES

The current level of access to ICTs for LDCs is quite low according to OECD. OECD came into force on September 30, 1961, and consists of 30 member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, France, Finland, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Slovak Republic, Turkey, the United Kingdom, and the United States. The purposes of OECD are to (1) "promote sound economic expansion in Member as well as non-member countries in the process of economic development" and (2) "contribute to the expansion of world trade on a multilateral, non-discriminatory basis" (OECD, 2002, p. 2). The OECD defines the ICT sector "as a combination of manufacturing and services industries that capture, transmit and display data and information technology. . . ." (OECD 2002, pp. 19, 81–82).

The OECD observes that at the international level the most basic and

Table 3

INTERNET HOSTS PER 1,000 INHABITANTS BETWEEN OECD AND NON-OECD COUNTRIES (OCTOBER 1997 TO OCTOBER 2000)

	1997	*1998*	*1999*	*2000*
OECD Countries	23.0	34.0	55.0	82.0
Non-OECD Countries	0.21	0.38	0.59	0.85

Source: Based on OECD (2001).

important indicator of the digital divide is the number of Internet hosts per 100 (or 1,000) inhabitants (OECD, 2001). A *host* is defined as "a domain name that has an IP (Internet Protocol) address record with it" (OECD, 2001, p. 40). An *Internet host* includes any computer connected to the Internet full-time or part-time and by direct link or dial-up access (OECD, 2001). Table 3 compares the number of Internet hosts between OECD countries and non-OECD countries over the 4-year period from October 1997 to October 2000. In 1997, there were 23 Internet hosts per 1,000 inhabitants in OECD countries as compared to 0.21 hosts per 1,000 inhabitants in countries outside of OECD. By October 2000, there were 82 Internet hosts per 1,000 inhabitants in OECD countries in contrast to 0.85 hosts in non-OECD countries (OECD, 2001). By July 2001, the number of Internet hosts in OECD countries reached 112 million persons. Other OECD data show that the United States had the highest number of Internet hosts, with more than 272 hosts per 1,000 inhabitants (OECD, 2002, p. 40). Canada, Finland, Iceland, and Sweden had around 180 Internet hosts per 1,000 inhabitants. In contrast, Mexico and Turkey had no more than 5 Internet hosts per 1,000 (OECD, 2002, p. 40).

Further, comparing the number of Internet hosts in OECD countries to the number of Internet hosts in countries in Africa may provide an even starker contrast. In Africa, where all countries are finally connected to the Internet (Eritrea was the last country connected in November 2000), most of these connections have only one Internet service provider (Miller, 2001). Some 90% of the Internet market in sub-Saharan Africa is in South Africa, where 90% of all users are in the main urban areas (Navas-Sabater, Dymond, & Junutumen, 2002). Moreover, although the number of Internet hosts provides an indication of the size of the Internet in a country, the number of active websites gives information on countries' relative development of Internet content. The United States, Germany, and the United Kingdom, respectively, have the most active number of websites (OECD, 2001).

Table 4

NUMBER OF INTERNET HOSTS PER 1,000 INHABITANTS BY GLOBAL GEOGRAPHIC REGION (OCTOBER 1997 TO OCTOBER 2000)

Region	*1997*	*1998*	*1999*	*2000*
North America	46.28	69.74	116.41	168.68
Oceania	26.81	34.76	43.84	59.76
Europe	6.13	9.45	13.41	20.22
Central/South America	0.48	0.91	1.67	2.53
Asia	0.53	0.87	1.28	1.96
Africa	0.17	0.21	0.28	0.31

Source: Based on OECD (2001).

Table 4 shows the number of Internet hosts per 1,000 inhabitants by global geographic regions from October 1997 to October 2000. Central and South America, Asia, and Africa have the lowest number of Internet hosts per 1,000 inhabitants. Africa is the least connected to the Internet of all the geographic regions. North America, Oceania, and Europe have the highest number of Internet hosts per 1,000 inhabitants. Given the higher Internet host penetration rates in industrialized global geographic regions, Graham (2002, p. 34) observes, "the Internet remains the preserve of a small global elite of between 2 percent and 5 percent of the global population." This condition has been called a *global ghetto* by the United Nations (United Nations Development Programme, 1999). Described another way, what has resulted is the concentration of electronic economic power in the hands of a small number of countries (or global firms) (Graham, 2002). The United States, Canada, and Europe combined represent approximately two-thirds of all the world's Internet users, and more than two-thirds of all Internet users in Asia are in the countries of Japan, Korea, Singapore, Hong Kong, and Taiwan (Navas-Sabater, Dymond, & Junutumen, 2002).

ICTs AND THE WORLD'S POOR

The World Economic Forum observes (2000, p. 9) that

> On every relevant measure—from size and penetration of telecommunications market or the extent of internet diffusion to level of global electronic commerce and so on—the vast majority of economic activity related to information and communications technologies is concentrated in the

> industrialized world. Conversely, developing countries, and especially, the least developed countries, account for a small fraction of the global digital economy.

Stated another way, ICTs are "irrelevant to the three billion people in the world who live on under two US dollars per day. A large majority of these individuals are in Sub-Saharan Africa and South Asia" (Pigato, 2001). "For an estimated 2 billion people, access to fresh water or electricity is a daily challenge of more fundamental concern than access to the information society" (Campbell, 2001).

Similarly, but in a more dramatic manner, Sachs (2000, p. 99) says,

> [T]oday's world is divided not by ideology but by technology. . . . A small part of the globe, accounting for some 15 percent of the earth's population, provides nearly all of the world's technology innovations. A second part, involving perhaps half of the world's population, is able to adapt these technologies in production and consumption. The remaining part, covering around a third of the world's population is technologically disconnected, neither innovating at home or adopting foreign technologies.

Poor individuals in LDCs have several common characteristics. First, as previously noted, they live on less than US $2 per day and in many instances less than US $1 a day. Second, they live in rural areas. Third, they are unemployed or subsist on farming or as unskilled wage laborers. Fourth, they are uneducated. Fifth, they are a part of minority ethnolinguistic groups. That is, they do not speak the official or most popular language of the country in which they live (Kenny, 2002). Each of these characteristics reduces the likelihood of poor individuals using the Internet and other advanced ICTs. In particular, the lack of education may significantly reduce Internet use in poor countries (Duncombe, 2000). Much of the world's poor live in Bangladesh, Brazil, China, India, Indonesia, Mexico, Pakistan, Russia, and on the continent of Africa.

Table 5 points out the global characteristics of the poor with respect to income, education and literacy, language, and rural conditions. There are only 7.4 personal computers and 7.9 mobile phones per 1,000 capita among the world's poor population. Only 46% of the world's poor women and 27% of the world's poor men are literate. Some 53% of the world's poor do not speak the official language in the country where they live. About two-thirds of the world's poor live in rural areas. The largest city in a rural area has only about 171 telephone lines per 1,000 inhabitants. Table 5 also points out that the radio is the most common electronic communication technology used by the world's poor. For more costly ICTs, the world's

Table 5
GLOBAL CHARACTERISTICS OF THE POOR

Income	*Poverty Weighted Average*
Poor Population (%)	36.4
Personal Computers (1,000 capita)	7.4
Fixed Telephone Lines (1,000 capita)	36.5
Mobile Phones (1,000 capita)	7.9
Radios (1,000 capita)	196.0
Education, Literacy, and Language	
Female Adult Literacy (%)	46
Male Adult Literacy (%)	27
Population Not Speaking Most Widely Used Language (%)	48
Population Not Speaking Official Language (%)	53
Rural	
Rural Population Total (%)	67
Fixed Lines (1,000) in Largest City	171

Source: Derived from Kenny (2002).

poor are unable to afford personal computers and telephones (even if telephone line connections are available).

The telephone is the most basic and necessary tool for access to ICTs and it "is the leading indicator for the level of universal service in telecommunications" (OECD, 2001). The telephone is also "a fundamental measure of the international digital divide" (OECD, 2001). One condition for accession to OECD is a country's commitment to provide universal telecommunications service and/or universal access including the Internet (Global Internet Liberty Campaign (GILC), 2000). Universal service is commonly viewed as a telephone in every household; universal access is seen as everyone being within a reasonable distance of a telephone (GILC, 2000). Access to telecommunications is critical to a country's commerce, public safety, governance, and overall human development (United Nations Development Programme, 2000). Yet, "one third of the world's population has never made a telephone call. More than 3 billion people have no money to spend on communications services, or live in rural or remote areas" (Commission of the European Communities, 2001, p. 2). As of 1999, each of the cities of New York, Tokyo, and the country of Thailand had more

Table 6

ICT CONNECTIVITY IN CENTRAL AND EASTERN EUROPE

Country	*GDP per capita (US $)*	*First commercial Internet connection*	*Phone lines*	*Teledensity**
Albania	1,290	Early 1990s	63,900	1.74
Belarus	5,000	1993	2,128,000	21
Bosnia-Herzegovina	600	1998–1999	326,000	8.9
Bulgaria	4,630	1989	2,647,500	32
Croatia	4,300	Mid-1990s	1,389,000	31
Czech Republic	11,100	1996	2,817,200	27
Georgia	1,350	1995	567,400	10.5
Hungary	7,500	1995	2,661,600	28
Macedonia	960	1995	367,300	17
Moldova	2,400	1995	593,300	14
Poland	6,400	Early 1990s	6,532,400	17
Romania	5,200	Early 1990s	3,161,200	14
Russia	5,200	?	25,914,500	17.5

*Number of telephone lines per 100 people.
Source: Derived from GILC (2000).

telephones and cell phones than the entire continent of Africa (Rice, 2001; United Nations Development Programme, 1999).

Table 6 shows the GDP per capita, year of the first commercial Internet connection, number of telephone lines, and teledensity for poor and relatively poor countries in Central and Eastern Europe, including the Czech Republic, Hungary, and Poland, which are members of the OECD. Albania and Bosnia-Herzegovina have fewer than 10 telephone lines per 100 inhabitants. Belarus, Bulgaria, Croatia (non-OECD countries) and the Czech Republic and Hungary (OECD countries)—have 21, 32, 31, 27, and 28 telephone lines per 100 inhabitants, respectively. The first commercial Internet connections occurred in most of the countries in the early to mid-1990s.

Telephone mainlines as well as the number of scientists and technicians are "technological inputs" (Campbell, 2001) that are required for the transference, application, and use of technological outputs (ICTs) (Rodriguez & Wilson, 2000). Instead, LDCs' poor populations have used the traditional ICT, the radio, as their "community telephone" (Kenny, 2002). Unlike other ICTs, the radio is the least expensive to operate and requires no literacy—only batteries. Kenny (2002) estimates the cost of operating

a radio for 2,000 hours per year (about 6 hours a day) is about US $0.01 per hour. Yet, even this amount exceeds poor individuals' expenditure of approximately US $10.00 on yearly communications (Kenny, 2002). Most countries' (except LDCs) households and individuals spend approximately 2% of their income on telecommunications (Navas-Sabater, Dymond, & Junutumen, 2002).

CONCLUSION

OECD countries have substantially higher investments than LDCs in technological inputs or soft infrastructures. OECD countries invest 9 times more in research and development, have about 17 times more technicians, and 8 times as many scientists per capita than sub-Saharan countries (Rodriguez & Wilson, 2000). In 1998, 72.1 per 100 inhabitants in OECD countries had telecom access (fixed and mobile) as compared to 7.8 per 100 for non-OECD countries. Some 30% of individuals in developing countries had Internet access as compared to 2% in LDCs (Commission of the European Communities, 2001, p. 2). High-income countries have 22 times as many telephone lines per 100 inhabitants as low-income countries (International Labour Organization, 2001). ICTs not only allow access to information and knowledge, they also enable and facilitate technologies, can be used to save time and money, and can improve the quality of both work and home life, whether in developed countries or LDCs. ICTs are increasingly playing an important role in a country's economic development, education, health, and well-being.

Even if LDCs significantly increase the application and diffusion of ICTs, an extremely important question remains: will the poor in these countries benefit? This question is important because of what the literature notes on income inequality in developed countries. For example, in the United States personal computer ownership and access to the Internet is highly associated with family income. The family income threshold is $75,000 (see Rice, 2001). Furthermore, ICTs benefit workers who possess greater levels of education. Educated workers are better able to use ICTs than low-educated or uneducated workers. This situation widens the ICT gap between low- and high-income individuals. Under this circumstance, in developed countries, ICTs reinforce existing patterns where individual skills, capabilities, and income are markedly different (Rodriguez & Wilson, 2000), and the "haves" benefit disproportionately from the application and diffusion of ICTs. Unlike poor and low-income persons, in developed countries, individuals with higher incomes take advantage of ICTs to

gain more resources for further growth and development. Therefore, without concentrated efforts in human capital development in LDCs, it would appear that ICTs may be contributing to a widening technological gap between developed countries and LDCs.

These points lead to a final set of observations. It is important that LDCs eliminate or reduce several significant barriers that impede technological transfer and technology development within their borders. These barriers can be placed into at least four categories: economic and financial, organizational, institutional, and human resources-related. First, LDCs have a poor economic base and low incomes, which provide little stimulus for savings and investment. Second, there are few or no incentives to encourage business and market development for technologies. Third, business and market structures in LDCs must advance from a monopoly or oligarchy to one of competition and fair pricing. This point raises the following question: to what extent do LDCs' government policies inhibit a competitive private sector or reserve significant economic activities for government controlled organizations (see Dasgupta, Hall, & Wheeler, 2002)? This question is important because, as Eggleston, Jensen, and Zeckhauser (2002) note, in a proper market structure environment, ICTs can enhance market functions for both producers and consumers, which can lead to a positive impact on the living standards of the poor. Fourth, LDCs need to enact explicit national policies that support technology acquisition and development and upgrading of indigenous skills and knowledge. These developments may lead LDCs to possess overall stronger capacities to assess their technology needs and, perhaps at some point, to influence global thinking on future technology development and technology research. Fifth, LDCs need to engage in human resource training and skill development in project development, management, and operations for application in technological organizations. These actions may serve to reduce the market efficiency gap and by extension the access gap between developed countries and LDCs, and perhaps facilitate technology transfer to LDCs through foreign direct investment and other means.

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