

The Global Impact of the Internet: Widening the Economic Gap Between Wealthy and Poor Nations?

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ABSTRACT *Does the Internet have the potential to accelerate development in poor nations? Or is it an innovation that will widen the gap between wealthy and poor countries? This paper places the Internet in a framework of major innovations in modern economic history that have contributed to increased global economic inequality. To study whether the Internet has the potential to do the same, we investigate the determinants of Internet diffusion and explore differences between developed and developing nations. Our findings indicate that developing countries are being left behind as the transformation to the 'new economy' takes place in wealthier countries. If this trend continues, it may have dire consequences for world economic inequality and political stability, as did great innovations of earlier eras. We consider policies that might accelerate the development of information technology in poorer countries so these nations can benefit from the technological revolution occurring in wealthier countries. We also discuss why it might be in the interest of the developed countries to pursue such policies.*

Keywords: digital divide, Internet adoption, economic development.

Introduction

The Internet and information technology (IT) represent a revolution that may well have an economic impact corresponding to waves of innovations that began with England's industrial revolution more than two centuries ago. Because these waves of innovation were exploited most in relatively few parts of the world, they dramatically increased global economic inequalities. Economic inequalities became associated with discrepancies in political power among nations. During the nineteenth and the first half of the twentieth centuries, these discrepancies led to imperialism and large-scale warfare. The last half of the twentieth century brought concerted efforts to reduce global economic inequalities, with mixed results at best.

Now the Internet and IT are at the core of a new wave of innovation that shows signs of further increasing global inequalities. This paper presents data that show a significant gap between wealthy and poor countries in the rate of diffusion of the

Internet. The evidence suggests that poor countries are being left further behind as a result of the ongoing technological revolution elsewhere in the world. We consider proposals for helping developing countries participate in the 'new economy' by improving their communications infrastructures and transferring technology from technological leaders to poorer countries, as well as whether it might be in the interest of leading nations to sponsor such efforts.

The latter part of the twentieth century witnessed a revolution in information technology, culminating at century's end by the Internet. Numerous popular and academic articles describe the 'new economy' and new business models stimulated by IT. Computers, databases and communications networks are pervasive in post-industrial countries. The Internet provides standards for worldwide connectivity, and its impact on business and commerce has been dramatic. The impact of IT on economy-wide measures of productivity is also increasingly evident, particularly but not exclusively in the United States, the leader in applying information technology. Litan and Rivlin¹ of the Brookings Institution undertook a large-scale study of the impact of the Internet on productivity, and estimated that the Internet has contributed 0.25–0.50% to annualized gains in productivity in the United States.

Web Inequality

The Computer Industry Almanac estimates that there are over 500 million users of the Internet world-wide today and that the number will more than double by 2005. A UN Human Development Report² noted that the lead of the US in Internet development has resulted in 80% of websites being in English and 26% of Americans using the Web, whereas only 3% of Russians, 0.04% of South Asians, and 0.02% of people in Arab states do so. The US has more computers (potential Web access) than the rest of the world combined. Moreover, while an American can buy a computer with a month's salary, a Bangladeshi would need 8 year's income to buy one. Nielsen estimates that 58% of US homes have Internet access as of July 2002. By implication, the reduction in worldwide economic inequality that occurred in the last half of the twentieth century is being reversed, contrary to the rosier scenarios of some economists who argue that the recent reductions in inequality are likely to continue in the twenty-first century.

The Internet is a kind of technological infrastructure, however, and developing countries are notoriously short of infrastructure. The Internet also requires a level of education and training to use, and educational opportunities in poorer countries are generally inferior to those in wealthy countries. Unfortunately, our data analysis shows that poor countries are almost 'off the screen' as far as Internet capabilities. The data suggest that what appear to be key determinants of the Internet's penetration in more developed country settings have almost no explanatory power for developing countries. If this situation persists most of the continued diffusion of Internet technologies will occur in wealthy countries, and the likelihood increases—based on the historical impacts of earlier network technologies—that economic inequality and political and social instability will increase in the world.

New Technologies and Economic Inequality among Nations: Historical Perspectives

Two to three centuries ago there was far less economic inequality among the world's major regions and societies than there is today. From then to the present,

Table 1. Real GDP per capita relative to world average, selected countries/regions, 1700–1998 (world average GDP = 100 at each date)

Year	UK	US	France	Japan	China	India	Africa	Latin America
1700	203	86	160	93	98	89	65	86
1820	256	188	184	100	90	80	63	100
1870	368	282	216	85	61	61	51	81
1913	326	351	231	92	37	45	39	100
1950	327	452	249	91	21	29	40	121
1973	293	407	320	279	20	21	33	110
1998	328	479	343	358	55	31	24	102

Source: Derived from A. Maddison, *The World Economy: A Millennial Perspective*, OECD, Paris, 2001, Table B-21, p. 264.

as is evident from Table 1, the gap in average income per person between rich and poor societies became much wider. In 1700, the UK was the richest country shown in the table, and its GDP per person was about three times that of a person in Africa, the poorest region, and about twice that of the other countries and regions in the table, as well as about twice the world average in 1700. Even in 1820, GDP per person in the UK was only 2.5 times the world average but three times that of China and India, and four times that of Africa.

Contrast the 1700 and 1820 figures with those for 1998, when the US was the richest country with a GDP per person almost five times the world average (and nearly six times the world average excluding the US). In 1998, the US figure is approximately nine times that for China, 16 times that for India, and 20 times that for Africa as a whole. At the extremes, US GDP per person in 1998 was 30–40 times the level of many individual countries in Asia and Africa, and more than 50 times the level in Afghanistan and Chad.

There are some other lessons in the figures given in Table 1. China, India, and Africa fell more and more behind world-average GDP per person between 1700 and 1950; since 1950, China and India have improved their relative positions, but Africa has fallen further behind. France in 1700, and for two centuries thereafter, was a relatively rich country, but one that lagged behind the UK; in recent decades it has caught up with and slightly surpassed the UK. Latin America has been close to the world average of GDP per person for three centuries; it is the large region that we might regard as typical of world experience during these centuries. And the US and Japan, albeit at different rates, moved from slightly below world average earlier in modern history to very far above world averages later.

What raised the gap between rich and poor nations from a ratio of 2 or 3 to 1 to a gap of 30, 40, or 50 to 1 in two centuries? And can we now expect the gap to be narrowed in the years, decades, and century ahead? Economists and economic historians are far from agreement on the answers to these questions. Some espouse a traditional view that major technological innovations associated with the industrial revolution for the past two centuries catapulted some nations and world regions ahead of others. Moreover, they suggest, history gives us reasons for optimism about eventually closing the gaps opened by the industrial revolution. Nations such as the US and Japan were once relatively poor, but they became

relatively rich. And more recently, nations such as India and China, by growing faster than the world economy as a whole, have reduced the gap between themselves and a steadily increasing world average of GDP per person. Proponents of this traditional view see advantages in being a latecomer to industrialization. Latecomers often grow faster than industrial pioneers, whose innovations they can implement without having to develop them on their own.

A newer view of modern economic history reaches more pessimistic conclusions about the possibilities for reducing gaps between the rich and the poor. In this view, the great economic gaps that emerged over the past two centuries resulted not from industrial technologies that can relatively easily be implemented by latecomers, but from waves of network technologies and network innovations. The innovators who took advantage of network effects or externalities rapidly moved far ahead of others so that gaps in relative incomes grew rather than declined. To the extent that such network technologies continue to develop, the rich innovative nations increase their lead, and the world becomes less, not more equal. The US is the prime example. Already the world's richest nation a century ago, the US has since increased its lead over most of the rest of the world, as Table 1 demonstrates. Now, as the prime innovator of Internet and IT, we expect it to continue to increase that lead.

Which of these two views is more nearly correct? We believe the more pessimistic view comes closer to the truth, for reasons we examine in detail below.

The Traditional View: Advantages of Latecomers

The first industrial revolution in England began with late eighteenth-century technological breakthroughs in the production of textiles, coal, and iron, and the innovation of steam engines. Traditional economic historians use these specific or 'core' examples of innovative change to develop general principles underlying industrialization. Spinning and weaving breakthroughs in textiles represent the general principle of substituting power-driven machines for human labor. Technological developments in iron (and coal) processing illustrate the substitution of abundant mineral substances for scarcer animal and vegetable materials. Steam engines generalize to the substitution of inanimate converters of energy for traditional animate (human, plant and animal) converters.³

Each specific technological breakthrough represented a quantum leap forward in production and the productivity of human labor. As the general principles involved were extended to other industries, economic growth—production per person—increased and became self-sustaining. From textiles, machine production spread to other industries. Iron led directly to steel, and as the chemical technologies involved were increasingly understood, a host of new materials were developed and used across a range of modern industries. Steam engines enabled the development of railroad locomotives, and became the forerunners of internal combustion engines to power automobiles, and nuclear reactors to generate electric power.

With these epochal developments, living standards rose, but they did not rise everywhere, or at the same rate in different societies. England, which by the mid-nineteenth century became 'the workshop of the world', and the US were the leaders among the larger countries. Continental Europe took up the technological revolution in the nineteenth century, during which time industrialization spread from Western to Central and, to a lesser extent, Eastern Europe. At the end of the

century Japan began a major industrial upsurge, and remained for decades the only non-Western country to be an industrial society. Among this group of industrializers, the followers or latecomers tended to grow faster than the pioneers, so that eventually the differences in income levels among industrial countries became much less than between them and the non-industrial rest of the world. Well into the twentieth century, the 'rest of the world' lagged well behind Europe, North America, and Japan; but in the second half of the twentieth century, it, too, began to industrialize.

This traditional account of the industrial revolution helps to explain the dramatic increases in economic inequality among nations that developed during the past two centuries. It also indicates how that inequality eventually tends to be reduced. The latecomers grow faster than the pioneers, reducing the income gaps that the industrial revolution initially engendered among them.

In a recent article, Robert Lucas,⁴ a prominent economic theorist and Nobel laureate, utilized these stylized facts of economic history to develop a model predicting that economic inequality in the world would be far lower 100 years from now than it is today. Latecomers to industrialization in Lucas's model grow faster than earlier industrializers by a factor proportional to the average income gap between the two groups; eventually eliminating the gap, and all industrialized countries grow at the same rate. As more and more of the world's countries industrialize, world economic growth slows down, and income gaps among countries are greatly reduced. According to Lucas, this phenomenon has been happening since the middle of the twentieth century, and it is likely to continue over the coming century as more or less the whole world becomes industrialized.

If Lucas is right, we need not worry, as does the UN's 1999 Human Development Report,⁵ about the tendency of the Internet and other new information technologies to increase inequality. They, too, will be incorporated into the world's stock of technology, and with some lag will be adopted by latecomers even more rapidly than by today's leaders. Eventually—maybe in 100 years—all or most countries will be at similar levels of income.

There are reasons, however, to doubt such a rosy scenario. Lucas's model, which does seem to capture some important facts of economic history, is deficient in others. It appears to assume that the world's stock of state-of-the-art technology is relatively unchanging or changing very slowly, so that latecomers can avoid the costs incurred by pioneers, and then by growing faster than the pioneers, eliminate the income gaps between them.

Suppose, however, that the Internet and related IT are really epochal innovations such those of the British industrial revolution two centuries ago, or the related railroad technologies that came along in the middle decades of the nineteenth century, or the electrical and automotive technologies that were developed in the late nineteenth and early twentieth centuries. If so, these new technologies, like the older ones just mentioned, might well increase inequality in the world for decades, with political and social consequences that do not differ from those that came with inequalities brought by industrialization after 1800.

A New View: The Power of Networks and Network Externalities

A new interpretation of economic history of the past two centuries puts the possibility that world economic inequality may increase in historical perspective. This new

interpretation, while not denying the importance of the great inventions and innovations of the industrial era, gives more emphasis to the importance of network innovations and network externalities in shaping the modern economic world.

In the new view, the Internet and IT are examples of fundamental network technologies that promoted and sustained industrialization where it took place. The earlier network technologies, in order of their appearance, were modern financial systems in the seventeenth and eighteenth centuries (before the industrial revolution), early transportation networks (road, canal, ocean and waterway shipping, and, most prominently, railway networks) from the late eighteenth to the late nineteenth centuries, and, finally modern transportation (highway, airway), communication (telegraph, telephone) and electrical networks which began in the late nineteenth and early twentieth centuries.

Each of these historical network breakthroughs can be associated with the industrialization of the modern world and the income gaps among nations and world regions to which 'selective' industrialization led. Financial systems were the first (and least recognized) of the great network technologies of the modern world. Three pioneers in financial systems were the Dutch Republic, the British, who adopted and extended Dutch financial techniques, and the US, which adopted and extended British financial techniques.⁶ These three countries early in their modern histories had what some have termed 'financial revolutions'. In all three, financial networks—banking systems and securities markets, for example—were in place to mobilize and allocate capital before the Industrial Revolution, so that the revolution could advance rapidly without capital-supply constraints. Although economic historians have been slow to recognize the relationship of financial development and economic modernization, nearly all of them, if asked to name the most advanced economies of the past four centuries, would say, in order, the Dutch Republic in the seventeenth and eighteenth centuries, Britain in the late eighteenth and nineteenth centuries, and the United States from the late nineteenth century to the present.⁷

The early transportation technologies of the nineteenth century, particularly the railways, which developed rapidly from their start in the late 1820s, were classic network technologies. Constructing railway networks was costly, and relied on financial-system networks already in place for funding. Countries (and individual entrepreneurs) that built and used the new railway network technologies earliest and to the greatest extent prospered the most, while others were left to catch up later, or left in the dust. Inequality widened.

Just as the range of applications of industrial technologies increased over time, so too did the range of network technologies. A third wave of network development occurred from the mid-nineteenth through the early twentieth century. First came the communications networks represented by the telegraph and the telephone. Then the automobile, followed by the airplane, created the need for new transportation networks, highways on land and air traffic systems for flight. Simultaneously, electrical networks spread and spawned a host of industrial and consumer applications. These innovations led to more inequalities of income and wealth between the rich and the poor of the world.

From the early decades of the twentieth century to the IT revolutions at its end, there were no great breakthroughs in network technologies. One has to wonder if the absence of major new network developments during much of the twentieth century might have created the sort of economic world envisioned in Robert Lucas's model. Without such technological developments, the have-nots of the

world could adopt older technologies already developed by the haves and catch up with them, as the model predicts. In other words, the poorer countries could install the infrastructure necessary to join the networks established earlier by the richer countries, and disproportionately benefit from doing so since they became members of large networks previously developed by others. By enlarging the network, their membership created network externalities for existing participants, who could now 'reach' more members.

With the Internet and other IT advances that have arrived in recent years, we appear to be on the edge of an era when economic inequalities in the world again increase, as they did in the wake of earlier financial, transportation, communication, and electrical network innovations. These past network developments bypassed many people and large areas of the world for long periods of time. Making the rich richer and leaving others behind seems to be a general characteristic of networks technologies.⁸ For these reasons we think it is important to examine the characteristics of the adoption rate of Internet technologies, which are still in their infancy, to determine whether the haves are advancing rapidly while the have-nots are lagging behind. If so, and the gap between rich and poor nations is once again rising, as it did in the wake of past network innovations, what are the implications?

The Growth and Distribution of the Internet

Which countries are using the Internet today? What is the extent of Internet use among developing countries? What factors predict the intensity of Internet use in a particular country? The answers to these questions are important in formulating policies to assist developing countries in taking advantage of technology.

Economic Growth Factors and the Internet

Landes⁹ has proposed the following factors for stimulating economic growth in developing nations:

1. Manage and build instruments of production; master the technological frontier.
2. Impart knowledge to the young.
3. Hire and promote based on competence and relative merit.
4. Encourage initiative, competition and emulation.
5. Allow people to benefit from their labor and enterprise.
6. Practice gender equality.
7. Have a political system that:
 - a. secures the rights of private property;
 - b. secures the rights of personal liberty;
 - c. enforces the rights of contracts;
 - d. stable government of laws rather than men (not necessarily democratic);
 - e. provides responsive and honest government;
 - f. moderate, efficient and non-corrupt government keeping taxes down.
8. Establish norms of honesty and avoid corruption in business dealings.

To successfully integrate the Internet into an economy, a country's leaders will have to follow many of Landes's suggestions. The instrument of production for the

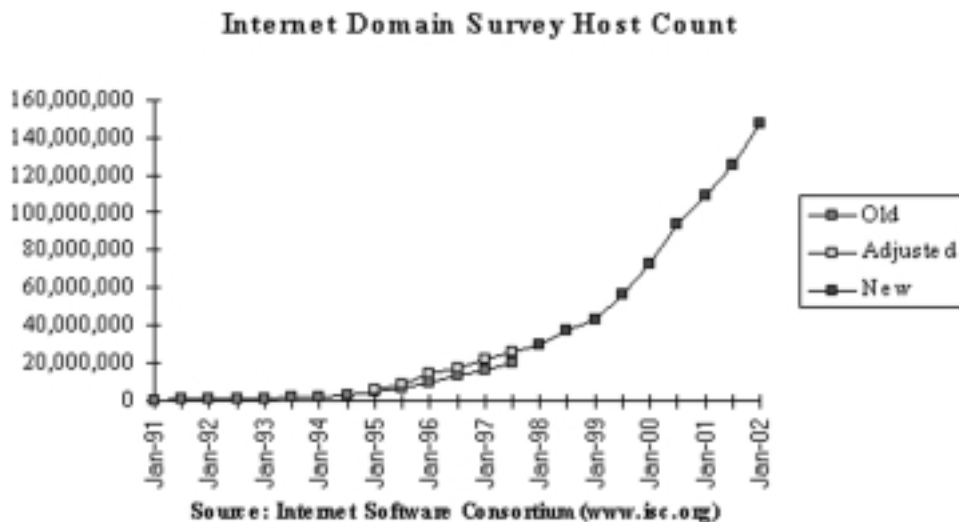


Figure 1. Internet hosts.

Source: <http://www.isc.org/>.

Internet is a telecommunications infrastructure, something that is expensive and competes with other infrastructure projects such as roads. While a developing country may be able to use wireless technology for phone connections and WiFi networks for geographically compact computer networks, high-speed long distance Internet access demands either fiber optic lines or satellite communications.¹⁰ (So called third-generation wireless systems offer the potential for reasonably high bandwidth with a cellular infrastructure, but the development of these systems has been slow.)

Knowledge is an important prerequisite for Internet use. Individuals have to learn how to use the Internet, and set up servers and websites. There is a need to transfer this knowledge to developing countries if they are to secure the benefits of the Net. Much of the development of Internet business has been entrepreneurial, which means that people have to be allowed to benefit from their labor and investments; there must be a right to private property and there is a need to honor contracts.

Research Design

We collected data from the World Bank¹¹ on 1998 economic development indicators, at the time the most recent numbers available. We added to these data information about the number of Internet hosts in each country from the Internet Software Consortium (ISC) at <http://www.isc.org/ds/>. Hosts are the computers on the Internet that contain content; they respond to requests from client computers. A country with a large number of hosts or servers is indicative of more Internet penetration and activity than a country with fewer hosts.

Figure 1 shows a recent survey of Internet hosts; note the exponential growth of the Internet over the last decade. Compared to other innovations like radio and television, the Net has grown considerably faster, especially since it became available for profit-making use in 1995. This rapid diffusion adds urgency to the

needs of developing countries; each day they delay developing an Internet presence, they fall further behind.

The Data

We obtained development-indicator and Internet-host data from the World Bank¹² and from a survey of Internet Domain names by the Internet Software Consortium [ISC at (<http://www.isc.org/>)]. There are some problems with the data. First, the World Bank data for different countries may not be for the same year due to different practices on collecting and reporting information in various countries. The Internet host data are based on high-level domain names. For example, a domain name that ends in 'com' generally is from the United States, while one that ends in 'sg' is from Singapore, 'ca' from Canada and so on. However, there is no law that says domain names have to reflect the physical location of the server. The Taliban government in Afghanistan had a Web server, but the host data showed no hosts in Afghanistan in 1998 or 1999. The server was probably in Pakistan.

Press¹³ reports on a number of errors in estimating the number of hosts in a country based purely on the domain name, and suggests that data from *Matrix Maps Quarterly* is a better source as it has been adjusted for misclassification of domain names. We purchased the MMQ data for the host count of July 1998; MMQ begins with the ISC data and then adjusts it. Comparing the two counts, the MMQ data generally adjusts the number of hosts in a country upward while correcting for over-counts in countries with a large number of hosts. However, none of the countries with fewer than 100 hosts in the ISC survey has 100 or more hosts in the MMQ data. The largest discrepancy is for Canada where MMQ estimates almost 600,000 more hosts than the ISC data show. MMQ also estimates a quarter of a million more hosts in Taiwan than ISC. In the analysis below, we estimate our basic model with combined data from both surveys. We use the MMQ data when it exists for a country, and the Internet Software Consortium estimate where it does not. (There was no material difference in the results below comparing the same analysis with the ISC survey and the combined, adjusted host count reported below.)

Variables in the Study

There is no accepted number of hosts for a country to be considered as having a major Internet presence. We chose to divide our sample of countries at the median host count for 1998, 632 hosts. The Appendix lists countries split at the median. Countries without much presence on the Internet may be found in Africa, the Middle East and parts of Asia.

Table 2 contains descriptive statistics on the two host subsamples in terms of the development-indicator variables in the study. We chose these variables to describe and compare countries with a well-developed presence on the Internet with those lacking such a presence, and to look at the relationship between conventional measures of economic development and Internet presence.

The variables include population and gross domestic product per capita adjusted for purchasing power and recorded in US dollars. IncomeF is an estimate of the percentage of the average income in a country that females earn; it is a

Table 2. Descriptive statistics

Name	Definition	Number of hosts < 632		Number of hosts ≥ 632	
		N	Mean	N	Mean
Pop	Population	107	9,451,217	92	50,391,809
Adjgdp	Adjusted GDP PPP \$	91	\$2,758	83	\$5,093
IncomeF	% average income of females	80	33%	83	33%
Lifeexpt	Life expectancy	91	60 years	83	72 years
Ltrate	Literacy rate	91	68%	83	90%
Roadpav	Paved roads	87	35%	80	61%
Phone1000	Phones/1,000 people	111	92	91	275
PCs1000	PCs/1,000 people	25	16	70	78
Hosts95	Internet hosts 1995	46	6	87	55,755
Hosts98	Internet hosts 1998	147	96	94	389,921
Host98Adj	Adjusted hosts 1998	147	105	94	380,738

Note that World Bank's *Knowledge For Development* Report 1999 uses phone density as a measure of population's ability to access information.

measure of gender equality in the workplace. Landes¹⁴ argues that gender equality is important for economic development so that the capabilities of the entire population, not just half of it, are applied to the economy. Life expectancy is a measure of health while literacy rate is indicative of educational levels in a country. The percentage of paved roads is a measure of physical infrastructure. In its 1999 *Knowledge for Development Report*, the World Bank uses the number of phones per 1,000 people as a measure of information access. PCs per 1,000 people is an indicator of technology diffusion, but unfortunately, there are too many missing observations to use this variable in the regression analyses which follow.

Comparing countries with fewer than the median number of hosts with those equal to or greater than the median, the adjusted GDP in the first group is 54% of that of countries having 632 or more hosts. The percentage of average income earned by women is nearly the same in each group. However, life expectancy and literacy rates are lower in the less-than-632-hosts group. This group with fewer hosts also has fewer paved roads, PCs and phones per 1,000 people than countries with 632 or more hosts.

The growth rate of hosts between 1995 and 1998 in the two groups of countries favors countries with less than the median number of hosts. However, the low host group grew from a small base, averaging six, to 100. This figure compares with over 380,000 hosts in the greater than median group. The countries with fewer than 632 Internet hosts in 1998 average three orders of magnitude fewer hosts than the countries having more than 632 hosts. OECD data confirms that developed countries, especially the US, are experiencing greater growth in Internet hosts than poorer nations. OECD data shows that between September 1999 and March 2000, the US added 25.1 Internet hosts per 1,000 inhabitants, the UK 5.5, Japan 4.1, Germany 3.0 and France 2.7 (*Wall Street Journal*, 21 June 2000). There is a significant gap between the countries with little presence on the Internet and countries that have a more substantial presence. Countries with fewer than the median number of hosts on the Internet are a long way behind those with a substantial Internet presence.

Predicting Internet Hosts

To answer the question of what characteristics of a country are associated with a presence on the Internet, we used the data described in Table 2 to predict the number of Internet hosts by country in 1998 divided by population. [The actual calculation is for the adjusted hosts (Host98Adj) divided by population times one billion; the equations below predict the natural log of this number.] The independent variables in the analysis for 1998 are the natural log of adjusted gross domestic product per capita, the literacy rate, the percentage of income earned by females, and phone density.

Equation (1) presents the results for the entire sample. (The numbers in parentheses under the variables are *t* statistics;¹⁵ please note that the number of countries in the analysis below is less than the number in Table 1 due to missing data for the independent variables.) Three of the four variables in the equation are significantly related to hosts divided by population, explaining 61% of the variance in the dependent variable. The adjusted gross domestic product is an indicator of wealth, literacy rate of education, and phones per 1,000 people of technology and communications infrastructure. As authors like Landes predict, wealth, education and infrastructure are associated with a greater presence on the Internet. It is interesting to note that our measure of gender equality, the percentage of average income going to females, does not predict the number of hosts. It may be that gender equality is fairly low in all countries except a few industrial democracies; Table 2 shows no difference in IncomeF between firms below and those at or above the median number of hosts.

Equation (2) presents the results of predicting hosts divided by population for countries with fewer than the median number of Internet hosts. Here, the model explains very little variance, only 21%. Adjusted gross domestic product and phones per 1,000 people are significant, but only at the 0.10 level.

Equation (3) applies our model to the data for countries at or above the median number of Internet hosts in 1998. The independent variables explain 84% of the variance in the number of hosts divided by population. Adjusted gross domestic product and phones per 1,000 people are highly significant in the equation.

All Hosts

$$\begin{array}{rcccccc}
 (1) \text{ LNHOST/POP} & + & 2.54 & & + & 5.21 \text{ E-02} & + & 5.57 \text{ E-02} & + & 9.24 \text{ E-03} \\
 = & -16.92 & \text{LNADJGDP} & & \text{LITRATE} & & \text{INCOME F} & & \text{PHONE1000} \\
 & & (3.94)*** & & (2.86)*** & & (1.38) & & (4.52)***
 \end{array}$$

Significance levels for *t* and *F* statistics * ≤ 0.10; ** ≤ 0.05; *** ≤ 0.01. Adjusted $R^2 = 0.61$; $F = 62.38$; $n = 160$.

Hosts < Median (632)

$$\begin{array}{rcccccc}
 (2) \text{ LNHOSTS/POP} & + & 1.72 & & + & 3.01 \text{ E-02} & + & 0.12 & & + & 2.51 \text{ E-02} \\
 = & -12.92 & \text{LNADJGDP} & & \text{LITRATE} & & \text{INCOME F} & & \text{PHONE1000} \\
 & & (1.68)* & & (1.04) & & (1.63) & & (1.85)*
 \end{array}$$

Adjusted $R^2 = 0.21$; $F = 6.13$; $n = 79$.

Table 3. Mean hosts by group over time

	Hosts 1995	Hosts 1998	Hosts 2001
Hosts < median in 1998	6	134	721
Hosts ≥ median in 1998	55,756	389,921	1,298,205

Hosts ≥ *Median* (632)

$$\begin{aligned}
 (3) \text{ LNHOSTS/POP} &+ 1.88 &+ 1.90 \text{ E-02} &+ 1.48 \text{ E-02} &+ 7.32 \text{ E-03} \\
 = &-5.66 &\text{LNADJGDP} &\text{LITRATE} &\text{INCOME} &\text{PHONE1000} \\
 &(4.70)^{***} &(1.52) &(0.79) &(9.84)^{***}
 \end{aligned}$$

Adjusted $R^2 = 0.84$; $F = 107.40^{***}$; $n = 81$.

Updating Host Data

The Internet is growing rapidly and our analysis only captures a cross section at a time when economic and demographic statistics were available. How much has the picture changed since these data were collected? To answer this question, we updated the host statistics in 2001, with the results shown in Table 3 below. We also ran regressions predicting 2001 hosts from 1995 and 1998 hosts. The regressions were highly significant for countries above the median in hosts in 1998, and insignificant for countries with fewer than the median number of hosts in 1998. While countries with fewer hosts are increasing their hosts at a high rate, they are dominated in absolute numbers by countries with a significant Internet presence. It appears from these data that the gap among nations on Internet participation continues to grow.

Discussion

The analysis demonstrates clear differences between countries that have embraced the Internet and those that have not. Landes's¹⁶ economic development factors help explain some of these differences. What leads to the development of the technological infrastructure represented by the Internet? Landes argues that wealth is necessary to produce capital and that education and gender equality are important for economic growth. These data support several of his conditions for development and extend them to technology infrastructure. Higher levels of Gross Domestic Product, higher levels of literacy and communications infrastructure are associated with greater Internet presence for all countries combined, though the effect of literacy does not appear in the two subsamples. In those countries having fewer than the median number of hosts, the independent variables have little predictive power. However, there is some evidence that wealth and communications infrastructure are important here. The results on wealth and communications infrastructure are much stronger for countries at or above the median number of Internet hosts. These disparities appear to be growing over time, not diminishing.

Recommendations

The UN Development Report data and the results above suggest a wide gap between countries that have adopted the Internet extensively and those that have not. The major factors associated with Net adoption are GDP and telecommunications infrastructure as measured by the number of phones per 1,000 people. For the countries with the lowest adoption in the analysis, these variables are only modestly associated with the number of Internet hosts, and the model explains little variance. The conclusion is inescapable that less developed countries are significantly behind on Internet technology compared to those with more resources.

Are the Internet and its associated technologies important for economic growth? The Litan and Rivlin¹⁷ study suggests that they are. Another study estimates a 10% increase in the relative number of Web hosts in a country is associated with 1% greater trade in 1998–99, a period coincident with the data reported in this paper.¹⁸ If the Internet is an important, transforming technology, then what are the policy implications? What factors inhibit the adoption of the Internet, and what can be done to mitigate them?

Barriers to Net Adoption

There are many barriers to the adoption of new technology; for example, Kedia and Bhagat¹⁹ stress general problems related to culture and social influence. Some countries tend to see the Internet as an American-dominated technology and therefore as something to be distrusted. In addition to cultural issues, the Internet requires a group of knowledgeable users to diffuse the technology to others. Many developing countries lack such a corps of dedicated IT professionals.

Many developing countries have undemocratic governments, which are concerned with the free flow of information. An Indonesian government minister said at a conference in Kuala Lumpur on 25 November 1997 that no one from the government had validated the information on the Internet. The opponents of the regime had a website that they did not submit to government censors. The minister complained that the Indonesian army set up a website to put forth its views, and no one accessed it! In addition to concerns over the control of information, governments may be worried about the ease with which dissident groups can communicate with each other through websites and email. Finally, the ability to access the Internet opens up a world of websites, over two billion pages of information at last count, some of which is critical of non-democratic forms of government.

Developing countries lack the funds for investing in a telecommunications infrastructure, purchasing computers, and providing education on how to use the technology. The lack of infrastructure, phones and PCs is a major impediment to Internet adoption. Where the infrastructure exists, Internet access is considerably more expensive in poor countries than in wealthy ones relative to income. In Ghana an account with Africa Online cost \$50 a month in 1999, nearly twice the monthly income of most Ghanaians. Ghana at least has competition in communications; a half circuit or local portion of the network is \$2,500, while in Kenya an ISP pays \$8,000 for a half circuit.²⁰ In Russia the price for an Internet connection is \$121 a month; adjusting for GDP per capita, Russian Internet users pay 485 times as much as users in Finland.

Proposals for Assistance

What sorts of policy measures might dramatically increase the adoption of the Internet and help poorer nations narrow their substantial technology gap with wealthier countries? And can they be justified? If the gap that we and others have identified between wealthy and poor countries continues to accelerate, and the Internet and IT revolution suggest that it will, poor countries will see stagnating living standards and incomes, while the wealthy countries become wealthier. This phenomenon has occurred before in modern history. An increased gap between the rich and poor tends to lead to an environment that encourages political instability, wars within and between nations, and a continuing cycle of misery for the people in affected countries.

Policy measures that might reduce such possibilities by diffusing more rapidly the benefits of Internet technologies throughout the world include:

1. a sustained effort by the United Nations and individual, wealthy countries to build the most appropriate communications infrastructure in developing countries;
2. the dedication of sufficient satellite transponders for two-way Internet access for poor countries using technology now available from DirecPC and Starband;
3. an Internet Corps within the UN or individual countries modeled after the Peace Corps. This group of aid workers would have as its primary responsibility establishing connectivity and training people in less developed countries on how to access the Internet and how to build websites. Part of the aid would be devoted to developing native language websites and content;
4. funding and assistance for poor communities to establish Internet access points, for example, in libraries, schools, post offices or town halls. In many places individuals will not be able to afford computers to access the Internet, but people could share one or more community computers. The Internet Corps above could provide training to a person in the community to maintain the computers and help users work with them;
5. a concerted effort by aid agencies to encourage government policies in developing countries that favor innovation, venture capital, investments in research, and education about technology;
6. a \$1 per month surcharge on the Internet accounts of every user in wealthy nations to fund the activities above, similar to the surcharge on US phone bills to connect schools to the Internet and provide phone service for low income subscribers;
7. a 1% tax on all electronic commerce dedicated to expanding Internet use in developing countries; and
8. an International Developing Countries Venture Capital Fund to allocate the capital raised in steps 5 and 6 above; some of the capital should be applied to infrastructure, and some to new ventures that involve the Internet.

While taxes and surcharges such as those in 6 and 7 above would not be popular, they can be justified on economic grounds. Substantial network externalities from the Internet and World Wide Web mean that both buyers and sellers benefit from increasing the number of users of the Net around the world. The more users connected to the Net, the more valuable the Internet is to content providers, who in turn, attract more users. Subsidies from rich to poor countries to increase the

Internet penetration can be justified on the grounds that the benefits of expansion of the network, initially at least, may be greater for existing members than for new ones.

The Internet phenomenon is as dramatic a revolution as were the industrial revolution and financial, transportation, communication, and electrical network breakthroughs that occurred during the past three centuries. Will wealthy nations stand by and see information technology widen the gap between rich and poor countries that resulted from the industrial revolution? Or will they, in their own interest, make an effort to reduce the gap between rich and poor through the substantial benefits the Internet can provide to developing countries? The choices wealthy countries make with regard to the Internet and the communications infrastructure of developing countries may well determine the economic future of half the world's population and the stability of large regions of the globe. Due to network externalities, the kind of assistance suggested here has the possibility of contributing as much to the countries offering aid as those receiving it. It is not too soon for concerted action, before the Internet gap between wealthy and poor countries becomes an insurmountable chasm, resulting in many of the negative consequences that arise from the uneven diffusion of industrial and network technologies in the world economy.

Notes and References

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9. Landes, *op. cit.*
10. DSL technology offers high speed Internet access over copper wire, but has a number of limitations.
11. World Bank, *Knowledge for Development*, World Development Report, Washington, DC, 1999.
12. *Ibid.*
13. L. Press, 'Tracking the global diffusion of the Internet', *Communications of the ACM*, 40, 11, November 1997, pp. 11–7.
14. Landes, *op. cit.*
15. The countries included in these results represent a census of countries having an Internet host, though not a census of all countries in the world. Given data that are more the census than a sample, it is probably not necessary to be concerned over statistical significance. However, most readers are familiar with *t* statistics and significance levels as one measure of the strength of a relationship, so they are included here.

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Appendix. Countries in the Study

Countries with hosts greater than or equal to the median 632 in 1998	Countries with hosts less than the median of 632 in 1998
Antarctica	Albania
Barbados	Algeria
Guam	American Samoa
Bangladesh	Angola
Channel Islands	Aruba
Korea, Dem. People's Rep. of	Ascension Island
West Bank and Gaza	Benin
Belarus	Bhutan
Brunei Darussalam	Bouvet Island
El Salvador	British Indian Ocean Territory
Georgia	Burkina Faso
Kenya	Burundi
Liechtenstein	Cambodia
Monaco	Cameroon
Namibia	Cape Verde
Nicaragua	Central African Republic
Oman	Chad
Panama	Christmas Island
Paraguay	Comoros
Zimbabwe	Congo
Bermuda	Cook Islands
Bulgaria	Cuba
Costa Rica	Dem. Rep. of the Congo
Croatia	Djibouti
Cyprus	Dominica
Dominican Republic	East Timor
Ecuador	Equatorial Guinea
Egypt	Eritrea
Guatemala	Ethiopia
Kazakhstan	Falkland Islands (Malvinas)
Kuwait	French Southern Territories
Latvia	Gabon
Lebanon	Gambia
Luxembourg	Grenada
Macau	Guernsey
Malta	Guinea-Bissau
Niue	Guinea
Pakistan	Guyana
Peru	Haiti
Philippines	Heard and Mc Donald Islands
Puerto Rico	Iraq
Tonga	Isle of Man
Trinidad and Tobago	Jersey
Venezuela	Kiribati
Virgin Islands (US)	Lao People's Dem. Rep.
Yugoslavia	Lesotho
Argentina	Liberia

Appendix (Continued)

Countries with hosts greater than or equal to the median 632 in 1998	Countries with hosts less than the median of 632 in 1998
Australia	Libyan Arab Jamahiriya
Austria	Madagascar
Belgium	Malawi
Brazil	Maldives
Canada	Mali
Chile	Marshall Islands
China	Martinique
Colombia	Mauritania
Czech Republic	Mayotte
Denmark	Micronesia, Federated States of
Estonia	Mongolia
Finland	Montserrat
France	Mozambique
Germany	Myanmar
Greece	Nauru
Hong Kong, China	Netherlands Antilles
Hungary	Niger
Iceland	Nigeria
India	Norfolk Island
Indonesia	Northern Mariana Islands
Ireland	Palau
Israel	Papua New Guinea
Italy	Pitcairn
Japan	Qatar
Korea, Rep. of	Reunion
Lithuania	Rwanda
Malaysia	Saint Kitts and Nevis
Mexico	Saint Lucia
Netherlands	Saint Vincent
New Zealand	Samoa (Western)
Norway	Sao Tome and Principe
Poland	Saudi Arabia
Portugal	Seychelles
Romania	Sierra Leone
Russian Federation	Solomon Islands
Singapore	Somalia
Slovakia	South Georgia and The South Sandwich Islands
Slovenia	St. Helena
South Africa	St. Pierre and Miquelon
Soviet Union	Sudan
Spain	Suriname
Sweden	Svalbard and Jan Mayen Islands
Switzerland	Syrian Arab Republic
Taiwan, Province of China	Tajikistan
Thailand	Togo
Turkey	Tokelau

Appendix (Continued)

Countries with hosts greater than or equal to the median 632 in 1998	Countries with hosts less than the median of 632 in 1998
Ukraine	Tunisia
United Arab Emirates	Tuvalu
United Kingdom	Uganda
Uruguay	United States Minor Outlying Islands
USA	Vanuatu
	Vatican City State (Holy See)
	Viet Nam
	Virgin Islands (British)
	Wallis and Futuna Islands
	Yemen
	Zaire
	Andorra
	Anguilla
	Antigua and Barbuda
	Armenia
	Azerbaijan
	Bahamas
	Bahrain
	Belize
	Bolivia
	Bosnia and Herzegovina
	Botswana
	Cayman Islands
	Cocos (Keeling) Islands
	Cote d'Ivoire
	Faroe Islands
	Fiji
	French Guiana
	French Polynesia
	Ghana
	Gibraltar
	Greenland
	Guadeloupe
	Honduras
	Iran, Islamic Rep. of
	Jamaica
	Jordan
	Kyrgyzstan
	Macedonia, FYR
	Mauritius
	Moldova, Rep. of
	Morocco
	Nepal
	New Caledonia
	San Marino
	Senegal
	Sri Lanka

Appendix (Continued)

Countries with hosts greater than or equal to the median 632 in 1998	Countries with hosts less than the median of 632 in 1998
	Swaziland
	Tanzania, U. Rep. of
	Turkmenistan
	Turks and Caicos Islands
	Uzbekistan
	Zambia