Policy Reform, Economic Growth, and the Digital Divide:

An Econometric Analysis

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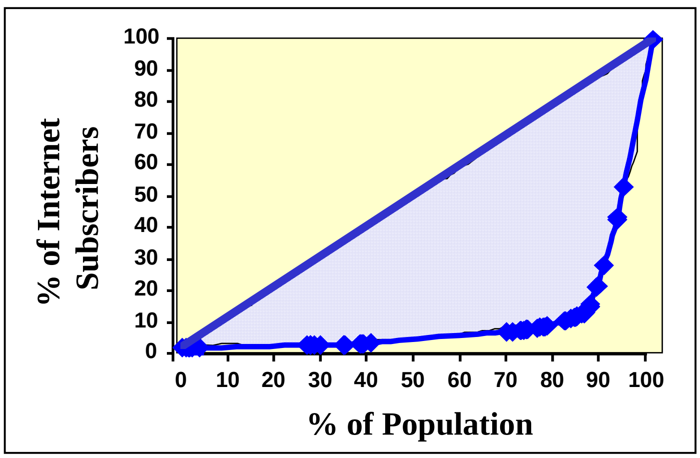
1. Introduction

Rapid growth of Internet use in high-income economies has raised the specter of a "digital divide" that will marginalize developing countries, because they can neither afford Internet access nor use it effectively when it is available. Dertouzos (1997) anticipates a widening income gap if the global Internet develops under laissez-faire conditions. The UN (1999) and Sachs (2000) concur, calling for substantial aid flows to narrow the technology gap. While Negroponte (1998) counters that the "leapfrog" character of the Internet will enable the poor to catch up quickly, he also advocates major increases in aid for technology development.

Current Internet access patterns highlight the potential severity of the problem. Figure 1 uses data on Internet connectivity (subscriptions per capita) to plot a digital Lorenz curve for 55 countries whose total population is 4.5 billion.[1] Severe inequality is evident, with 90% of the world's Internet subscribers in countries whose population is 15% of the global total. If this imbalance persists, it seems likely to damage the future growth prospects of many low-income countries.

Figure 1: International Inequality in Internet Access, 2000



In this paper, we investigate the sources and evolution of the digital divide using a new dataset. We focus on two dimensions of the problem: Internet use and telecommunications access. In Section 2, we review the anecdotal evidence on Internet use in developing countries. Drawing on this evidence, we specify and estimate a model of Internet diffusion via mainline telephone systems in Section 3. Sections 4-5 extend the modeling exercise to mobile telephone systems, whose rapid technological evolution may accelerate the spread of Internet access. In Section 6, we use the results to assess the potential role of economic and sectoral policy reform in narrowing the digital divide. Section 7 considers the potential for direct promotion of Internet access as a complement to policy reforms, and Section 8 concludes the paper.

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[1] Internet subscriber estimates have been provided to the World Bank by Pyramid Research, a subsidiary of the Economist Intelligence, Ltd.

2. Internet Use in Developing Countries: Anecdotal Evidence

Although futurists regularly extol the Internet's potential benefits for poor countries, skepticism is common among development researchers. Duncombe (2000), for example, argues that Internet access may mean little to poor Africans because lack of education will prevent them from using the technology effectively. In Duncombe's typology,[2] telephone systems require no literacy for independent operation while high literacy and language skills are prerequisites for using e-mail and other Internet services. Presumably, this distinction applies to technology use by poor Asian and Latin American households as well.

Limited anecdotal evidence suggests that this typology may be too restrictive. Where Internet services are available, poor households do not seem hesitant or incompetent to use them. Anand (2000) reports active participation by poorly-educated village women in an Internet-based rural information system in Pondicherry, India. Similarly, Bayes (1999) notes the rapid adoption of e-mail as a cost-effective alternative to telephone calls by poor families in Bangladesh. Village women in Lethem, Guyana have used an Internet connection to sell hand-crafted hammocks for as much as $1,000 each (Romero, 2000). Faiola and Buckley (2000) report that Ashaninka Indian villagers in Peru have raised their incomes 10% by using the Internet to market organically grown oranges in Lima. In a recent survey of over 100 developing-country manufacturers, Rajkumar (2000) finds that using the Internet has significantly expanded their customer base, sales, and exports. The new service seems to have been particularly helpful for small enterprises with lower-wage, lower-skill employees. Similar findings have emerged from a survey of north Indian small enterprises by Lal (1996).

These cases, while promising, do not fully address Duncomb's concern because specially-trained personnel often maintain such pilot systems. For example, the weavers of Lethem, Guyana have depended on the Internet skills of a village student who was sent to the capital, Georgetown, for special training. The Peruvian Ashaninkas have depended on six tribal leaders who received eight weeks of computer training from the sponsoring agencies. In Uganda, a pilot community telecenter operates through trained personnel who access the Internet for clients (IDRC, 2000). According to Arunachalam (1999), the Pondicherry center cited by Anand (2000) also relies on the skills of specialized staff.

One counter-example is offered by Mitra and Rana (1999), who report the results of an experiment with a high-speed touch-screen Internet link in a slum area of New Delhi. The link was provided to the community with no instructions and very little guidance, but local children demonstrated remarkable facility in learning how to use the Internet. Mitra and Rana conclude that formal training may be unnecessary for basic Internet access, although more advanced applications will undoubtedly require some instruction.

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[2] Duncombe (2000), Fig. 5, p. 40.

3. Econometric Evidence

While they provide useful information, such anecdotes can only offer suggestive insights. In this paper, we use newly-available data for a more systematic assessment of cross-country growth in Internet intensity, or Internet subscriptions per telephone mainline. We focus particularly on the impacts of income, government policy and urbanization. Widespread concern about the digital divide reflects the view of Duncombe (2000) and others that human resource constraints may significantly reduce Internet use in low-income countries. If they are correct, then income per capita should be a major determinant of Internet intensity. A second potentially-important factor is government competition policy, which may affect both the supply of Internet services and the intensity of their use by local firms. Our proxy for this variable is the World Bank's rating of competition policy in its Country Policy and Institutional Assessment database. According to the database glossary, this rating "assesses whether the state inhibits a competitive private sector, either through direct regulation or by reserving significant economic activities for state-controlled entities. It does not assess the degree of state ownership per se, but rather the degree to which it may restrict market competition." The index varies from 1 (most inhibition of a competitive private sector) to 6 (least inhibition). As Table 1 shows, it does not automatically consign poor countries to poor ratings. In our econometric exercise, we test the proposition that Internet intensity grows more rapidly in countries with high competition policy scores.

Table 1: World Bank Index: Government Inhibition of Competition in the Private Sector (1999)

	Degree of Inhibition of Private-Sector Competition		
Region	**Low (4-5)**	**Medium (3)**	**High (1-2)**
Africa	**Uganda** **Botswana** **Malawi**	**Cameroon** **Ghana** **Nigeria**	**Somalia** **Liberia** **Congo (Rep.)**
Latin America	**Guatemala** **Brazil** **Peru**	**Bolivia** **Costa Rica** **Venezuela**	**Ecuador** **Paraguay**
Asia	**Malaysia** **Philippines** **Bangladesh**	**China** **Indonesia** **India**	**Laos** **Vietnam**

We also include urban population in the model, to test the hypothesis that network economies cause Internet intensity to grow more quickly in urbanized societies. Although it would be useful to estimate price and quality elasticities for telephone services, we do not have sufficient data to include these variables.

We test the impact of income, policy and urbanization using a Gompertz technology diffusion model first introduced by Chow (1983). In this model, a technology's adoption rate (n) is directly proportional to the log difference between current use and long-run equilibrium use (the latter determined by a set of exogenous variables X_j).

$$(1)\ \dot{n}_t = \theta[\log n_t^{*} - \log n_t]$$

For estimation, we approximate this relation as

$$(2)\ \log n_t - \log n_{t-1} = \theta[\log n_t^{*} - \log n_{t-1}]$$

where

$$(3)\ \log n_t^{*} = \beta_o + \sum_j \beta_j \log X_{jt}$$

Substituting and adding a random error term we obtain the following estimating equation:

$$(4)\ \log n_t - \log n_{t-1} = \theta\beta_0 + \sum_j \theta\beta_j \log X_{jt} - \theta \log n_{t-1} + \varepsilon_t$$

We fit the model to cross-country data on the growth of Internet intensity from 1990 to 1997, using the following equation and variables:

$$(5) \log N_{jt} - \log N_{jt-1} = \theta\beta_0 - \theta \log n_{jt-1} + \theta\beta_1 \log U_{jt-1} + \theta\beta_2 \log Y_{jt-1} + \theta\beta_3 \log C_{jt-1} + \sum_k \theta\gamma_k R_k + \varepsilon_{jt}$$

where

N_{jt} = Internet subscribers/telephone mainlines
U_{jt} = Size of urban population
Y_{jt} = Income per capita
C_{jt} = Index of competition policy[3]
R_j = Vector of regional dummy variables (Sub-Saharan Africa, Middle East/North Africa, Asia, Latin America)

Data on Internet subscribers and telephone mainline connections have been supplied by Pyramid Research, a subsidiary of the Economist Intelligence Unit that specializes in telecom data. We have drawn measures of income per capita and urban population from World Bank sources, along with the competition policy index.

We summarize the estimation results in Table 2. Although the 44-country sample is not large, the regression statistics are quite robust. The model explains about 96% of total sample variation in the growth rate of Internet intensity. The estimated value of the diffusion parameter is almost exactly one and highly significant, suggesting little adjustment lag beyond the 7-year span of the data. Estimated elasticities for urban population and competition policy are large, positive and highly significant (.83 and .59, respectively, after accounting for the estimated value of θ (1.04)). The competition policy result is particularly important, because policy changes can occur relatively quickly. Suppose, for example, that an African country adopts measures that improve its

[3] We have used the 1995 value of this index in the regression because earlier values are not available.

competition policy rating from 2 to 3. Our results suggest that this change (a 50% improvement) will increase Internet intensity by approximately 30%.

Table 2: Regression Results for Equation (5)

Dep. Variable: Log $(I/T)_{1997}$ - $Log(I/T)_{1990}$[a,b]	
Variables	
Constant	**-14.76**** **(7.3)**[c]
Log $(I/T)_{1990}$	**-1.04**** **(31.8)**
Log $(Urban\ Population)_{1990}$	**0.86**** **(12.1)**
Log $(Income\ Per\ Capita)_{1990}$	**-0.10** **(0.7)**
Log $(Policy\ Index)_{1995}$	**0.61**** **(2.1)**
Asia	**1.68**** **(4.1)**
Latin America	**1.15**** **(3.9)**
Middle East, North Africa	**-0.04** **(0.1)**
Sub-Saharan Africa	**1.26**** **(2.9)**
Observations	**44**
R^2	**.97**
Adjusted R^2	**.96**
F-Statistic	**135.1**

[a] I/T = Total Internet subscribers/total mainline connections
[b] Minimum Internet connections set to 1 unit in 1990
[c] t-statistics in parentheses; White heteroskedasticity-consistent standard error and covariance estimates
** Significant at .05 or greater by the standard criteria

The income parameter estimate contrasts strongly with the policy result: Economic development does not have a significant impact on Internet intensity. Indeed, African, Asian and Latin American countries appear (ceteris paribus) to have higher Internet intensities than their counterparts in the OECD. This result is obviously not consistent with the conventional view of the digital divide, which highlights the role of the human resource gap and other development-related variables. A possible counter-argument is that rapid growth of Internet intensity in low-income countries will stall once the urban "elite" (i.e., the small minority of high-income households) have all subscribed. At present, we do not have sufficiently-disaggregated data to test for this kind of discontinuity. However, relatively high-income urban households in developing countries have significantly lower average incomes and education levels than their status counterparts in the OECD economies. For this reason, it seems reasonable to suppose that development would register strongly in the early years of Internet diffusion if it were an important determinant of intensity growth. In any case, the available evidence suggests that differences in competition policies have much greater impact on Internet intensity than differences in income.

While income apparently has no impact on Internet intensity (Internet subscriptions per telephone mainline), it obviously has an effect on Internet connectivity (per capita Internet use). The sample countries used to construct Figure 1 fall into three groups whose connectivity differs by orders of magnitude. Group I (50 - 400 subscribers/'000) includes the OECD economies, along with two NIE's (Korea, Singapore) and one Middle Eastern oil state (UAE). Group II (10 - 50 subscribers/'000) includes the more highly-developed economies of Eastern Europe and Latin America, along with Malaysia and South Africa. Group III (0-10 subscribers/'000) includes all other Sub-Saharan African states and low-income countries in Asia, Latin America, Eastern Europe and the Former Soviet Union.

This striking difference between intensity and connectivity suggests that the digital divide is not really new. It reflects a long-standing disparity in telecommunications access, rather than an additional handicap for developing countries.

4. Telecom Innovation and Future Internet Access

During the 1990's, most users accessed the Internet by connecting a PC to a telephone line via modem or, in the case of large businesses and universities, to a high-speed internal network. Much of the pessimism about Internet use in low-income countries stems from the belief that it will continue to require skilled use of costly PC systems. However, low-cost Internet access devices are rapidly appearing. For developing countries, the most promising innovation may be the Wireless Application Protocol (WAP), a universal open standard for bringing Internet content to mobile telephones.[4] WAP will be embedded in every new digital cellular phone by June, 2001 (IDC, 2000), and these phones will be sold in Africa, Asia and Latin America as well as in the OECD economies.

Data transmission rates via WAP-enabled cell phones should converge rapidly with rates that are currently available on high-speed corporate and university networks. Harrow (2000) reports that currently-available technologies can transmit wireless data at ISDN-level speeds (144 Kilobits/sec.); DSL-level speeds (1 Megabit/sec. (Mb)) are imminent; and several leading cell-phone suppliers have projected access speeds of 5.2 Mb by 2003.

[4] For detailed information on WAP systems, see www.wapforum.org.

WAP-enable cell phones are spreading very rapidly in Japan and Western Europe. According to the Japanese Ministry of Posts and Telecommunications, approximately 10 million Japanese users accessed the Net through mobile communications devices in May, 2000 -- an expansion to 40% of total Internet users since the advent of wireless access (Reuters, 2000).

After analyzing recent growth trends, IDC has projected a worldwide user base of over 700 million mobile Internet subscribers by 2002, significantly exceeding its projection of 500 million users who will access the Net through phone lines and wired networks (IDC, 2000). Anticipating rapid expansion of WAP-enabled phones, hardware manufacturers are developing color displays and input devices that will approach PC functionality in very small devices. During the next few years, mobile telephone systems appear poised to join telephone mainlines and cable TV as major platforms for Internet expansion in developing countries. Mobile phone systems have particularly important implications for the digital divide, because they can expand rapidly into peri-urban and rural areas where most poor households are located.

5. Explaining Mobile Telephone Growth in the 1990's

During the 1990's, privatization and deregulation of telephone systems accelerated access to telecom services in many developing countries. China's telecom penetration rate rose 25-fold (from 6 to 147 per thousand population); India's 33-fold (from 1 to 33); Latin America's quintupled (from 48 to 248); and Sub-Saharan Africa's rose more than twofold (from 5 to 13). Latin America's current penetration rate is more than half of the OECD rate in 1990; South Africa and East Asia (excluding China) are not far behind.

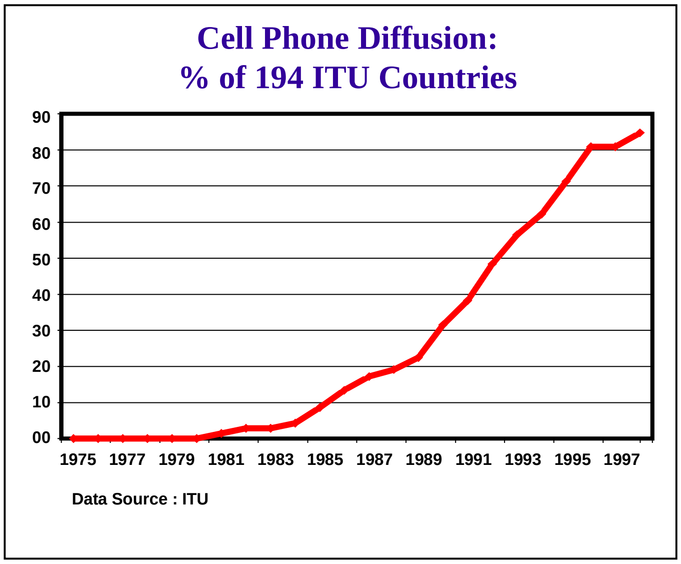
The most significant feature of this growth has been the spread of mobile phone systems. Figure 2 shows that mobile systems now operate in 85% of the International Telecommunication Union's 194 member countries. From a near-zero base in 1990, mobile subscriptions have increased to nearly 45% of fixed subscriptions in East Asia (excluding China); 40% in South Africa; 35% in Latin America; and 30% in China, Sub-Saharan Africa (excluding South Africa), and the Middle East-North Africa region.

While rapid growth has been the rule, developing countries have exhibited very different rates of increase and patterns of regional diffusion. In Latin America, annual mobile phone expansion rates have varied from 4% (Guyana) to 171% (Bolivia). In Asia, the growth rate has varied from 28% (Thailand) to 98% (China). Recent data on the spread of mobile telephone systems within developing countries show that geographic coverage is not necessarily limited to a few large cities.[5] In Africa, for example, mobile phone systems are rapidly moving toward coverage of the most populous regions in Senegal,

[5] National coverage maps for the GSM (Global System for Mobile Communications) are available from the GSM consortium's Website at www.gsmworld.com. Comparison with population distributions is possible using high-resolution population density maps available from the National Center for Geographic Information and Analysis, University of California at Santa Barbara, at http://www.ncgia.ucsb.edu/pubs/gdp/pop.html#GLOBAL.

Cote d'Ivoire, Uganda and South Africa. In other countries (e.g., Guinea, Sierra Leone), coverage is largely confined to the capital cities.

Figure 2: International Expansion of Cellular Telephone Systems



To explain these wide variations, we employ another version of the diffusion model in equation (4) for the period 1990 - 1999. We include initial income, policy and urbanization, while adding an income growth term to allow for changes during the 1990's. Recognizing that the growth rates of income and mobile phones may be jointly determined, we have tested the impact of mobile phone growth on income growth in a separate instrumental-variables exercise.[6] Finding no significant impact, we have employed a single-equation model (6) for this paper.

$$(6)\quad \begin{aligned} &\log M_{jt} - \log M_{jt-1} = \theta\beta_0 - \theta \log M_{jt-1} + \theta\beta_1 \log U_{jt-1} + \beta_2\theta \log Y_{jt-1} + \theta\beta_3 \log C_{jt-1} \\ &+ \beta_4(\log Y_{jt} - \log Y_{jt-1}) + \varepsilon_{jt} \end{aligned}$$

where

M_{jt} = Mobile telephone subscriptions
U_{jt} = Size of urban population
Y_{jt} = Income per capita
C_{jt} = Index of competition policy

Table 3 reports the regression result, which explains about 77% of the variation in mobile phone growth rates across 99 countries. All estimated parameters have the expected signs and are highly significant by the conventional criteria. The estimated value of

[6] Our growth equation replicates a recent specification by Easterly (2000), with the addition of a term to capture the possible effect of mobile phone growth. Results are available from the authors on request.

Table 3: Regression Results for Equation (6)

Dep. Variable: Log (Mobile)$_{1999}$ - Log (Mobile)$_{1990}$[a]	
Variables	
Constant	**-9.16**** **(3.2)**[b]
Log (Mobile)$_{1990}$	**-0.84**** **(13.0)**
Log (Urban Population)$_{1990}$	**0.78**** **(6.7)**
Log (Income Per Capita (IPC))$_{1990}$	**0.78**** **(3.0)**
Log (Policy Index)$_{1995}$	**1.06**** **(2.5)**
Log (IPC$_{1999}$) - Log (IPC$_{1990}$)	**2.12**** **(4.0)**
Observations	**99**
R^2	**.78**
Adjusted R^2	**.77**
F-Statistic	**49.8**

[a] Minimum mobile subscriptions set to 1 unit in 1990
[b] t-statistics in parentheses; White heteroskedasticity-consistent standard error and covariance estimates
** Significant at .05 or greater by the standard criteria

θ (.84) suggests very rapid adjustment toward long-run equilibrium subscription levels in the 1990's. The estimated elasticities for urban population, income per capita and pro-competitive policy are positive, large and highly significant (.93, .93 and 1.26, after accounting for the estimated value of θ). Income growth during the 1990's also has a large estimated elasticity (2.12).

Here we see strong evidence of the digital divide: Across countries, long-run equilibrium subscriptions have an approximately unit-elastic relationship with income per capita. This implies a large, persistent gap between high- and low-income countries, at least until the former achieve very high rates of penetration. The urban population result suggests that network economies provide a significant advantage for more urbanized societies. However, the results for the World Bank index and economic growth also suggest that policy matters a great deal. Income growth induces mobile phone expansion with an elasticity greater than two. Although recent studies of economic growth assign increased importance to exogenous shocks (Easterly, et. al., 1993; Easterly, 2000), they continue to find that countries with liberal economic policies enjoy a significant growth advantage.

The estimated elasticity for competition policy implies that measures which improve a country's policy rating from 2 to 3 will increase long-run equilibrium mobile phone subscriptions by 63%. In the regression result, this is equivalent to 68% higher income[7], or about nineteen years of economic growth at the recent average rate for low-income countries (2.8%). Income remains a prime determinant of the digital divide, but our results suggest that appropriate economic and competition policies can sharply narrow the gap.

6. Policy Reform and Access Expansion

To illustrate the implications of policy reform, we use the parameter estimates in Table 3 to predict future mobile telephone growth under different policy regimes. Our baseline forecast for 2000 - 2009 substitutes current values of three righthand variables (urban population, income, the World Bank competition policy index) for the earlier values used in the regression. We use each country's actual log-difference in income for the 1990's as our forecast for that variable. To simulate strongly pro-competitive policy, we set the World Bank index at level 5 for all sample countries. While this would require substantial reform in many countries, it has already been attained by Uganda, Malawi, Botswana, Guatemala, Brazil, Peru, Philippines, Malaysia and Bangladesh, among others Table 1). Assuming general adoption of more liberal economic policies and no adverse shocks in the world economy, we also set annual income growth at 5% (the upper quartile rate for our sample countries in the 1990's). Experiments with separate simulations have shown that each component (policy rating of 5; 5% annual growth) is responsible for about half of our projected change

Table 4 summarizes the projections in millions of subscriptions for Asia and Latin America, while Table 5 reports results in thousands for Sub-Saharan Africa to facilitate comparisons among countries in that region. Even the baseline projections suggest very rapid changes ahead. China dominates the Asian estimates, with projected growth from 24 million subscribers in 1998 to 102 million in 2009.[8] India's projection is more moderate but still impressive, with growth from 1 million users in 1998 to 21 million in the baseline projection and 42 million in the more optimistic forecast. Large gains are also projected for the other eight Asian countries in the sample.

The baseline results for 16 Latin American countries indicate growth from 18 million mobile subscribers to 80 million, while the more optimistic forecast is 145 million. Argentina and Brazil account for over half of the total increase. More moderate gains are projected for the Middle East and North Africa, but the optimistic scenario still projects over 17 million subscribers in the six sample countries by 2009.

[7] To produce this estimate, we divide .63 by the mobile-phone-growth elasticity of income (.93, after accounting for θ).

[8] In Table 4, China's baseline projection is higher than the "optimistic" projection because its growth rate in the 1990's was significantly higher than 5% per year.

Table 4: Mobile Telephone Diffusion in Asia, North Africa, and Latin America

Region/Country	Population (Millions) 1997	Population (Millions) 2009	Mobile Phone Subscribers (Millions) 1998	Mobile Phone Subscribers (Millions) 2009 (Baseline)	Mobile Phone Subscribers (Millions) 2009 (Growth 5%; Policy = 5)	Pop % With Mobile Phones (5/5 Forecast)
EAST ASIA						
China	1,227	1,399	23.9	102.0	81.9	6
Cambodia	11	15	0.1	0.1	0.2	2
Korea (Rep. of)	46	52	14.0	24.2	36.5	70
Lao P.D.R.	5	7	0.0	0.1	0.2	3
Malaysia	21	28	2.2	5.9	8.2	30
Philippines	73	96	1.6	3.7	12.1	13
Total (Excl. China)	156	197	17.9	33.9	57.3	29
SOUTH ASIA						
India	961	1,152	1.2	20.8	41.5	3
Bangladesh	124	150	0.1	1.9	3.6	2
Pakistan	137	193	0.2	2.4	6.8	4
Sri Lanka	18	21	0.2	0.7	1.2	6
Total (Excl. India)	279	364	0.5	5.0	11.6	3
LATIN AMERICA						
Argentina	36	42	2.8	23.9	29.0	69
Bolivia	8	11	0.2	0.4	1.1	10
Brazil	164	194	7.8	26.2	61.9	32
Chile	15	18	1.0	11.7	9.1	50
Colombia	38	47	1.8	4.7	14.1	30
Costa Rica	4	5	0.1	0.3	1.0	19
Dominican Rep.	8	10	0.3	1.2	2.2	22
Ecuador	12	16	0.3	0.3	2.1	14
El Salvador	6	8	0.1	0.7	1.1	14
Guatemala	11	15	0.1	0.7	1.4	9
Honduras	6	9	0.0	0.5	1.6	19
Nicaragua	5	7	0.0	0.3	0.6	8
Panama	3	4	0.1	0.5	0.8	21
Peru	25	32	0.7	4.6	6.4	20
Uruguay	3	3	0.2	1.3	2.3	73
Venezuela	23	30	2.0	2.0	9.4	32
Total	368	451	17.6	79.5	144.8	32
MIDDLE EAST, N. AFRICA						
Egypt	60	76	0.1	2.9	7.1	9
Jordan	4	7	0.1	0.6	1.1	15
Lebanon	4	5	0.5	2.2	1.5	30
Morocco	28	35	0.1	1.4	4.4	12
Tunisia	9	11	0.0	1.2	2.9	26
Yemen	16	27	0.0	0.1	0.3	1
Total	121	162	0.8	8.5	17.3	11

Table 5: Mobile Telephone Diffusion in Sub-Saharan Africa

	Population (Millions)		Mobile Phone Subscribers (Thousands)			
Region/Country	1997	2009	1998	2009 (Baseline)	2009 (Growth 5%; Policy = 5)	Pop % With Mobile Phones (5/5 Forecast)
SUB-SAHARAN AFRICA						
South Africa	38	47	2,500	3,651	14,574	31.3
Angola	11	16	10	58	726	4.6
Benin	6	8	6	77	230	2.7
Botswana	1	1	23	191	484	37.7
Burkina Faso	11	15	3	40	183	1.2
Burundi	7	10	1	3	40	0.4
Cameroon	14	20	7	701	4,518	22.9
Cote d'Ivoire	15	21	91	252	1,012	4.8
Ghana	18	25	49	804	2,590	10.5
Guinea	7	10	22	132	412	4.3
Kenya	28	38	11	298	1,783	4.7
Lesotho	2	3	10	49	102	4.0
Malawi	10	14	11	39	139	1.0
Namibia	2	3	20	114	276	10.2
Niger	10	15	1	26	167	1.1
Nigeria	118	166	20	732	3,640	2.2
Senegal	9	13	22	138	554	4.4
Tanzania	31	44	38	90	483	1.1
Togo	4	6	8	31	217	3.8
Uganda	20	29	30	250	321	1.1
Zambia	9	13	5	59	296	2.4
Zimbabwe	11	14	55	200	1,027	7.1
Total Outside South Africa	344	482	441	4,285	19,199	4.0

In Sub-Saharan Africa (Table 5), the baseline forecast is 3.7 million South African subscribers and 4.3 million in the other Sub-Saharan countries. Cameroon, Ghana and Nigeria figure most prominently in these projections. In the optimistic case, subscriptions outside of South Africa grow to 19.2 million.

While these African projections large in absolute terms, they still imply very low per-capita subscriber rates. At least another decade of rapid expansion after 2009 would be required for convergence with current OECD penetration rates, even under optimistic assumptions. To illustrate the problem, the last column in Table 5 provides estimates of mobile phones per capita in the optimistic scenario. Only a few countries have sizable penetration rates by 2009: Botswana (38%), Cameroon (23%), Ghana (11%) and Namibia (10%). In Latin America, by contrast, the optimistic scenario projects penetration rates close to current rates in the OECD. Particularly striking examples in Table 4 are provided by Argentina (69%), Uruguay (73%) and Chile (50%). Brazil's forecast is 32%, but this reflects a huge user base (62 million, up from 8 million in 1998).

7. Benefits of Access Promotion

Our results suggest that countries with progressive economic and sectoral policies will narrow the digital divide substantially during the coming decade. Large telecom access gaps will persist, however, and particularly for poor households. Targeted intervention could narrow the divide, but social opportunity costs are high in countries where basic educational and health services remain scarce. Are access subsidies warranted? Our own results are cautionary, since we find no causal role for mobile telephone expansion in economic growth during the 1990's (Section 5). However, Easterly (2000), Hardy (1980) and Roller/Waverman (1996) find a significant growth-promoting role for telephone connectivity, and many other studies suggest that telecom expansion has increased the incomes of poor households. These studies have documented three major sources of change: income for telecom service providers, reduced costs for household producers who use these services, and increased incomes from better market information.

Income for Telecom Service Providers

Provision of telecom services has become a source of income for many households in developing countries. In urban India, the state telecommunications company provides metered telephones to micro-entrepreneurs (Pitroda (1993)). These operators, who are frequently handicapped, charge cash for calls and are billed six times per year by the telephone service. Their bills are discounted 20-25% as a commission for their services. According to Ramadorai (2000), India currently has 2 million urban kiosks, each of which earns from $US 460 to 690 per year. In rural Bangladesh, Richardson, et. al. (2000) report that operators in Grameen's Village Phone program earn a net income of about $US 300 per year. This is 25% of household income for the operators, who are usually women with incomes below the local average (Bayes, 1999). The Village Phone program currently employs operators in 950 villages and plans to expand services to 40,000 villages. Bayes reports an average household size of 6.2 for operators, so a fully-implemented program would increase income by about 33% for 250,000 rural villagers. Fuchs (1998) reports that 1,000 rural telecenters in Senegal created approximately 4,000 new jobs during the period 1992-95 and generated an average net income of $1,600 dollars per year for their owner-operators. According to Braga, et. al. (2000), at least 6,000 telecenters are now operating in Senegal.

Income for Telecom Service Users

A few systematic studies of telecom's impact on user incomes have been undertaken in South Asia. These studies identify two major sources of increase in incomes: expansion of contact with family expatriate workers, leading to increased repatriation of earnings, and increased revenues for farmers who can get price information without relying on quotes from local middlemen. Pitroda (1993) cites a government study of the impact of a new telephone exchange on a town of 5,000 in Karnataka, India. During the year following installation of a 100-line exchange, the results suggest a rapid expansion of business activity, establishment of frequent communications with relatives in North America and Europe, and an increase of 80% in local bank deposits. In a sample-based statistical comparison of villages with and without Village Phone services in Bangladesh, Bayes (1999) finds price differences of approximately 7% for paddy, 8% for eggs, and 9% for foreign exchange, all attributable to improved knowledge of market conditions. The World Bank (1999) reports a much larger benefit -- price increases of 55% -- for farmers in Sri Lanka who have access to telephones.

Consumer Surplus Measures

While direct estimates of income and employment impacts are useful, more general welfare measures provide the best summary information about the value of telecom services to poor households. Using a variety of methods, numerous studies have estimated consumer surplus in this context (the difference between households' actual payments for telecom services and the amount they would be willing to pay).[9] Saunders, et. al. (1994) report savings between 2.5 and 5.5 times the cost of a telephone call in Andhra Pradesh State, India; 4 times telephone rental cost in Egypt; 10 times the cost of business calls in Kenya; and between 13.5 and 20.1 times the cost of telephone calls in Northern Luzon and Northern Mindanao, Philippines. The same publication reports that measured revenues from 92 public phones in 82 Costa Rican villages represent only 81% of the benefits received by telephone users. The Asian Development Bank (1996) reports savings of 2.6 times the cost of telephone calls in rural Thailand. For the Bangladesh Village Phone program, Richardson, et. al. (2000) estimate consumer surplus at 3-10% of mean monthly household income. Torero (2000) finds that increased access to residential phone services in Lima, Peru since privatization has generated an annual per capita consumer surplus of approximately $US 40 for very low-income consumers, $28 for low-income consumers and $146 for medium-income consumers. Since Peruvian income per capita is approximately $2,500 per year, these are significant benefits.

Cost-Effective Intervention

While telecom benefits for the poor seem substantial, access promotion programs may be undermined by institutional defects such as corruption, costly administration and benefits capture by more affluent households. Wellenius (1997) argues that the public sector can promote access cost-effectively through appropriate use of economic incentives. In Chile, for example, the government has promoted access for rural communities by auctioning targeted subsidies to private telecom operators. Coupled with careful monitoring of service delivery requirements, this approach has broadened access for low-income Chilean households at very low unit cost to the public sector. India (Ramadorai, 2000), Bangladesh (Richardson, 2000) and Senegal (Fuchs, 1998) have rapidly expanded

[9] For a general survey of the evidence, see Bedia (1999).

telecom access through micro-credit to small entrepreneurs whose revenues are more than sufficient to cover incremental service costs. Although such documented cases remain limited, the available evidence suggests that poor households value telecom services so highly that rapid expansion is possible at relatively low cost to the public sector.

8. Summary and Conclusions

In this paper, we have investigated the determinants of the "digital divide" between high- and low-income countries. Surprisingly, we find that there is no gap in Internet intensity (Internet subscriptions per telephone mainline). Controlling for other factors, developing countries have intensities as high as those of developed countries. While we find no reflection of the human resource gap in this context, our results suggest that policy differences matter a great deal. We conclude that the digital divide is not really new, but reflects a long-standing gap in per-capita availability of mainline telecom services. After identifying mobile telephones as a promising new platform for Internet access, we have studied the determinants of mobile telephone diffusion during the past decade. Our results show that income differentials matter, but they also highlight the critical role of progressive policies. Policy simulations based on our results suggest that feasible reforms could sharply narrow the digital divide during the next decade for many countries in Africa, Asia and Latin America. Our review of the literature also suggests that access promotion would yield substantial benefits for poor households, and that cost-effective intervention strategies are available.

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