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Telecommunications Reform, Internet Use and Mobile Phone Adoption in the Developing World

PHILIP N. HOWARD
University of Washington, United States
Center for Advanced Study in the Behavioral Sciences, United States

and

NIMAH MAZAHERI *
University of Washington, United States

Summary. — How do telecommunications policies influence technology adoption? Has regulatory reform helped mitigate or exacerbate the digital divide? We examine the effects of four policy reform strategies on a country's share of internet bandwidth, internet hosts, internet users, personal computers, and mobile phones. We argue that the best policy environment for the telecommunications sector is one maintained by an independent regulator that is not above representing the public interest or entering into public private partnerships to develop national information infrastructure. Holding other factors constant, privatizing the national telecommunications operator only has a few demonstrable effects, and the effects are mixed. Liberalizing the market for consumer communications services and separating the telecommunications regulator from direct control by the executive branch of government are, for the most part, constructive policies for encouraging technology adoption. Yet over time, too little public policy oversight usually has a negative impact on technology adoption. Regulatory independence mitigates against the digital divide, but regulatory withdrawal exacerbates it. Our findings offer greater coverage than prior research, and emerge from a time-series cross-sectional study of multiple technology indicators in 154 countries during the period 1990–2007.

Key words — digital divide, internet, mobile phones, policy reform, time-series cross-sectional analysis, developing countries

1. INTRODUCTION

On October 24, 1995, the Federal Networking Council formally defined the term "internet" as an information system that linked computers together by assigning them a unique address. That same year, the National Science Foundation defunded the "NSFNet," an early internet backbone, and effectively privatized the internet by redistributing funds to regional networks that could then buy internet connectivity from the private, long-haul communications networks that were emerging. These two events—formally defining the internet and opening up the infrastructure to development *via* the private sector—helped launch the digital communication infrastructure that would foster a rapidly unfolding information society in the United States. For many other countries, however, the emergence of an information society still remains in its nascent stages. Indeed, especially when one compares countries located at opposite ends of the economic development spectrum, the notion of a "digital divide" in access to information and communication technologies may be better described as a "digital chasm." While 7 out of every 10 people in the United States reported ever using the internet by 2008, only 7 out of every 100 people reported doing so in India, and only 7 out of every 1,000 people in Mali reported doing so.

Since the 1990s, a growing number of global development and international communication scholars have been examining the causes of this digital divide, whether or not it is narrowing, and determining what individual countries can do to improve technology adoption. While divergent findings occasionally emerge, the common approach has been to quantitatively evaluate the digital divide. Specifically, indices of the global *diffusion* of information and communication technologies (ICTs) have been utilized that measure various aspects of a country's "network readiness," patterns of internet access and usage, or the costs of digital technologies for governments and consumers (Dutta & Lopez-Claros, 2005; World Economic Forum, 2002). [1] Though significant insights have been generated from these studies, it should be recognized that most have examined wealthier countries or a regional subset of countries while constructing either static models or ones that comprise only a few years of data at best.

We advocate considering alternative approaches to examining the global digital divide. For one, time-series cross-sectional studies covering a broad range of cases and time periods that include many non-OECD countries can now be constructed in order to explore the determinants of the digital divide as it has changed. In addition, an alternative to

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diffusion-based studies is also possible, such as one that focuses on the global *distribution* of ICTs which uses measures of the relative proportion of a particular ICT infrastructure or usage that is available in a country. At the same time, more attention can be focused upon the impact of state policy reform on the digital divide. Finally, we argue that the global digital divide should not be assessed merely in terms of internet use, but through the various technologies that form the infrastructural basis of modern information societies: including internet bandwidth capacity and internet hosts, as well as personal computers and mobile phones.[2]

In the study of policy reform in telecommunications, Noll has convincingly argued for closer attention to the ways in which particular reform strategies may have an impact on the adoption of new information and communication technologies within a country (2000). In order to address these concerns, we conducted a large-*N* analysis of a panel of 154 countries from 1990 to 2007 using indices for the distribution of internet bandwidth, internet hosts, internet users, personal computers, and mobile phones that are weighted by gross domestic product (GDP). We begin by discussing the literature on the causes of the digital divide. We then present our approach to studying this process using measures of ICT distribution instead of ICT diffusion. Next, we move on to our data section and present our time-series cross-sectional study. Following this, we provide an interpretation of our results and a brief conclusion. Our study advances the research in three respects: we analyze a larger panel of countries over a longer period than has been covered in much previous research; we analyze a more comprehensive suite of digital information technology indicators including mobile phone use; rather than using static regression models, we conduct a time-series cross-sectional analysis using the latest data imputation techniques. We demonstrate that regulatory independence mitigates the digital divide, but that too much regulatory withdrawal exacerbates the digital divide.

2. WHAT POLICY REFORMS ALLEVIATE THE DIGITAL DIVIDE?

Understanding the causes and consequences of the digital divide has recently become a popular and highly contested area of research. Yet the stakes of properly understanding the digital divide are significant, since information technologies play an increasingly important role in social development around the world (Acemoglu & Robinson, 2000; Boas, Dunning, & Bussell, 2005; Cartier *et al.*, 2005; Evans, 2005; Kaushik & Singh, 2004; Parente & Prescott, 1994; Weber & Bussell, 2005). Indeed, some research has already pointed to a strong positive relationship between access to information and communication technologies and a country's level of income, as well as its prospects for democracy (Quibria, 2002). However, the causes of the digital divide are not yet clear as the scholarly debate often produces competing causal explanations, weighs the effects of regime type and policy reform in different ways, and produces a veritable laundry list of potential predictors. During most of the 1990s, the digital divide was primarily one that was technical in nature: international connections to the internet were made through dial-up services, few countries had their own domain names, and few countries had the capacity to maintain (much less manufacture) computer technologies. But with the growth in numerous kinds of digital communication technologies over the last decade, it has become clear that studying the digital divide by comparing *per capita* measures of internet users or internet hosts can expose only part of the digital divide.[3]

Historically, most of the world's technologies were pooled through scientific exhibitions that allowed developing countries to compare technical systems and choose the best technologies to meet their national needs (Fischer, 1992; Hughes, 1983; Rogers, 2003). More recently, market-driven international adoption and complex patterns of diffusion have emerged that are not simply explained by regime type or economic wealth (Howard, 2007). Often, individuals adopt a particular technology but do a significant amount of work adapting and redesigning it to fit their own needs and capabilities. As one example, consider the alternative kinds of digital technologies that people around the world use to connect to the internet. Mobile phones have now become an important way of accessing the internet, especially in poor countries where connectivity through mobile phone providers is relatively cheap and ownership of personal computers is relatively expensive. Indeed, the number of connected mobile phones has surpassed the number of computers connected to the internet. Global differences in technical standards and capabilities, diverging market prices of various technologies, and the presence of local adaptations and innovations all make the process of technology diffusion both uneven and complex—and understanding the digital divide all the more difficult.

Early research found that economic factors far outweighed others in determining on which side of the digital divide a country fell, but recent studies suggest that political and social variables can also have an impact (Corrales & Westhoff, 2006; Milner, 2006; Norris, 2001). For many of the large-*N* studies, income, education, telecommunication infrastructure, and the regulatory system are all key determinants of technology diffusion (Caselli & Coleman, 2001; Chinn & Fairlie, 2004). In Dedrick, Gurbaxani, and Kraemer (2003) study of 31 countries during the period 1985–95, for instance, the authors find that a country's economic structure, income level, telecommunication infrastructure, and human capital best explain cross-national patterns of investment in ICTs.[4] However, other studies have pointed to the role of literacy, core-periphery status in the world economy, as well as a country's level of "cultural cosmopolitanism" as statistically significant predictors (Guillén & Suarez, 2005). When many of these large-*N* studies attempt to evaluate the impact of regime type or politics on technology adoption, however, they do so with very broad indices of democratic character, or perception rankings of the general business environment. In contrast, we suggest it is crucial to focus on the public policy reforms that governments initiate specifically to improve technology adoption.

Pohjola's (2003) analysis of 49 countries during the period 1993–2000 concluded that not being an agricultural economy was furthermore important in predicting the amount of ICT investment in a country.[5] Additionally, Kiiski and Pohjola (2002), in examining a panel of 60 countries from 1995 to 2000, found relevance for the role of income, telephone access costs, and level of schooling on the number of internet hosts in a particular country. Mann and Rosen (2002) further point out in their study of 21 Pacific rim countries that, over time, high access charges and a lack of political freedom are negatively associated with rates of internet diffusion. Goolsbee and Klenow (2002), as well as Kiiski and Pohjola (2002), both conclude that a dense urban population and extensive telecommunication network are key factors behind the adoption of new technologies. Finally, several studies find that a country's degree of property-rights protections and level of regulation of the telecommunication sector also matter (Chinn & Fairlie, 2004; Wallsten, 2005; Weber & Bussell, 2005).

Democracies may also be more likely than autocracies to promote the spread of internet use and internet-related ICTs,

as Milner's (2006) study of 190 countries over the time period 1991–2001 shows. Yet both democracies and dictatorships top the list of rates of growth for information technology use, so in more authoritarian regimes income may be more powerful an indicator of rapid technology adoption (Corrales & Westhoff, 2006). Moreover, Johnson and McGlinchey's (2005) close examination of several Central Asian countries reveals that unstable democracies may actually be *more* likely to restrict internet service providers than confident authoritarian regimes. Similarly, Kalathil and Boas (2003) find that authoritarian regimes may significantly develop their digital communication infrastructure specifically as a means of extending the reach of the state (Chase & Mulvenon, 2002; Diebert, 2008). Finally, Li, Qiang, Zhen-Wei, and Colin (2005) argue that telecommunications reform may not be dependent on factors of regime type so much as on the degree to which financial elites and local consumers have already made large investments in existing infrastructure.

In spite of many studies on the economic, demographic, and infrastructural causes of the digital divide, the effect of telecommunications policy reform is less well understood. A debate has already emerged in regard to the role that privatization of the telecommunication sector can play in a country's adoption of new kinds of communication tools (Milner, 2006). For one, Guillén and Suarez (2005) provide evidence from 61 countries during the period 1997–2001 to show that a country's level of internet use is associated with its level of privatization and competition in the telecommunication sector. Also, Wallsten (2005) finds that certain characteristics of regulatory regimes—such as agency independence, transparency, and discretion—are able to explain the growth of internet users and internet hosts in 45 countries in 2001. The econometric study of 86 developing countries by Fink and Kenny demonstrated that complete telecom liberalization pays off by increasing the number of main telephone lines in *per capita* terms by 8% (Fink & Kenny, 2006). Caselli and Coleman (2001) find evidence that the larger the size of a government, the smaller the computer adoption rate across a country; they also maintain that the rate of computer diffusion across the countries is associated with sound property-rights protection.

Much insight has been gained from the existing literature on the digital divide. Yet there is a need to explain the variation in the global distribution of ICTs, and the comparative impact of public policy reforms on national development. Relying on studies that utilize a single point in time (Beilock & Dimitrova, 2003; Volken, 2002) or comprise only a few years of transition (Bauer & Maitland, 2002; Oxley & Yeung, 2001) can only provide a certain degree of analytic purchase. While there is a growing research into telecommunications reform in developing countries, much of the literature reviewed above covers OECD countries (Gutierrez, 2003). Moreover, most of the aforementioned studies rely on very broad perception indices of how the political liberties or the business environment may have an impact on technology adoption. By not doing a thorough time-series cross-sectional analysis, most of these studies also suffer from the known effects of Markov chains. What factors can explain improvements in a country's share of the global distribution of a particular ICT? What role can a state's telecommunication policy play in affecting this distribution?

3. TELECOMMUNICATIONS POLICY REFORM AND TECHNOLOGY ADOPTION

There are four common public policy reforms that have been applied in developing and developed countries alike. The first reform strategy for "modernizing" the sector is often to privatize the national telecommunications provider. By selling off a controlling interest in the national telephone company, political leaders hope to expose the organization to market pressures for efficiency and profit. The second strategy is to then break the provider's domestic monopoly over the consumer services market. Market liberalization introduces competition by allowing other firms to build mobile phone networks, resell long-distance services, and to sell a range of consumer electronics. Many states have relinquished their parastatal phone company to private hands and liberalized markets for communication services, but still maintain a regulatory body to manage the use of the public spectrum, set content rules, and administer broadcast licenses.

Thus, a third common reform is to give this agency independence from direct political oversight. For many years in many countries, the telecommunications regulator was a political agency under the direct supervision of the executive of government, and its appointments both a political sinecure and a means of shoring up control of public assets. The fourth tactic—more difficult—is to do more than merely separating the regulator from the head of state in terms of legal reporting relationships and to effectively depoliticize the agency. This fourth reform means professionalizing the staff making decisions about telecommunications policy and appointing technocrats instead of political leaders to senior positions. Depoliticization is often accompanied by very aggressive deregulation, and instead of having legislators actively involved in sectoral issues, technical experts make rulings and solve issues with little public involvement.

In recent years many governments have reformed their telecommunications sector, sometimes because of loan conditionality, and sometimes because of a political interest in a national ICT strategy. Since there is evidence that policy reforms may have an impact on technology adoption, answering the questions above must involve assessing the impact of the most common types of policy reform. By examining the effects of each of these four policy reforms on the distribution of various ICTs in over 150 countries over the span of nearly two decades, we will be able to move closer to a better understanding of what both states and markets do to alleviate as well as exacerbate the digital divide.

4. DATA

To examine how a state's telecommunication policies and other factors influence its relative share of the global supply of information technologies, we compiled a dataset for 154 countries, on internet bandwidth, hosts and users, personal computers, and mobile phones over the period 1990–2007 (ISC, 2008; ITU, 2008; World Bank, 2008). For our dependent variables, we used these data to create an annual index of each country's portion of global technology supply to its relative share of global economic output (Howard, Busch, & Cohen, 2008; Howard, Busch, Nafus, & Anderson, 2009). [6] Weighting for economic output is important in order to emphasize the distributional aspect of our measure of the digital divide. Doing so allows us to not just index how many mobile phones are in a country, for example, but to determine whether there are more or fewer mobile phones than expected given how wealthy the country is. This index relates the amount of technology in a country to the global supply of that technology in a given year, and then weights that ratio by the economic wealth of that country. This index is created through a ratio of two ratios. First, we calculate a ratio of a country's

technology use to the technology use of all countries in a given year. Then we calculate a ratio of a country's economic output to the output of all countries in a given year. The ratio of these two ratios reveals whether a country has about the expected proportion of ICTs, given its productivity. Half the distribution of possible values from this ratio of ratios ranges from 0 to 1 (disproportionately small share of computers in a country given its GDP) and the other half ranges from 1 to $+\infty$ (disproportionately large share of computers in a country given its GDP). However, by taking the natural log of the ratio of ratios the index will become more balanced: from $-\infty$ to 0 becomes less than proportionate share, and from 0 to $+\infty$ becomes more than proportionate share. This expression arrives at whether a country's supply of personal computers is in balance with its share of global economic product:

$$\text{Technology Distribution Index}_T = \ln\left(\frac{\frac{PC_{country}}{\sum_{world} PC}}{\frac{GDP_{country}}{\sum_{world} GDP}}\right).$$

Countries at the bottom end of the resulting index for a year have fewer computers than expected given their economic productivity; countries at the high end have more computers than expected given their economic productivity.[7] Of our dependent variables, internet bandwidth capacity is a measure of the amount of data that users can transfer over an internet connection, and is valued at megabits per second. If the incoming speed is different from the outgoing speed, the outgoing speed is used. Internet hosts refer to the number of computers in a country that are directly linked to the worldwide internet network; one internet host provides access to many internet users. The national count of internet users is usually estimated by national service providers, and is the best estimate of the size of the population able to access and use the internet in a country. Internet users refer to the number of people that have used the internet at any point in time during a particular year.[8] The number of personal computers in a country is reported by national telecommunications agencies to the International Telecommunications Union. Cellular mobile telephone subscribers refer to the number of users of portable telephones subscribing to an automatic public mobile telephone service.[9] We believe that to study the impact of public policy choices on the digital divide it is necessary to assess the outcome in terms of multiple indicators, because the networked, digital infrastructure so crucial to information societies has these multiple components. Altogether, this suite of five indicators includes the speed of connectivity, the number of computers connected to the internet hosting digital content, the number of people going online each year, and the two primary means by which people around the world use digital communication networks—personal computers and mobile phones. To weight these indicators for economic productivity, we use annual GDP PPP at constant price to account for inflation rates in international comparison.

For the independent variables, we control for a country's level of integration into the global economy using two variables: a measure of the percent of a country's GDP that comes from trade and a measure of the percent of a country's GDP that comes from foreign direct investment. The influence of demographic factors on a country's index of ICT distribution is also controlled for by including three additional independent variables: a log transformed measure of a country's total population, the percentage of a country's population living in an urban area, and the percentage of a country's adult literate population. To hold the effect of power infrastructure constant, we include a log transformed *per capita* measure of a country's kilowatt hours of power consumption. Data for foreign direct investment (FDI), trade, population, urban population, literacy, and power consumption were taken from the World Bank (2008). Literacy data were supplemented with additional information from UNCTAD and the CIA World Factbook (UNCTAD, 2008). As a measure of the effect of regime type on the proliferation of digital information technologies, we include the seven-point index of authoritarianism developed in the Freedom House's *Freedom in the World* dataset. This measure averages scores for civil and political liberties, with more authoritarian regimes earning higher scores (Freedom House, 2008).[10]

To test the impact of different state telecommunication reforms on a country's share of the world's number of a particular ICT, eight independent variables were created to reflect the important telecommunication-specific policy tools that states have at their disposal. We consider the four most common policy options for reforming the telecommunications sector: privatizing the national service provider, liberalizing the consumer market for communications services, separating the regulatory authority from direct control of the executive branch of government, and depoliticizing the appointment of regulators. For each of these, we created a binary variable to indicate whether or not the country had implemented the reform. Then we created a variable to indicate the number of years for which each type of reform had been in effect. This way, we capture both the effect of introducing a reform and any compounding effect over time as the reform becomes fully institutionalized.

For instance, we address the issue of privatization of the state-owned telecommunication provider by constructing both a binary measure of whether or not a country has privatized this sector and a count measure of the number of years since privatization. The determinant of privatization is defined as the year in which the government first sells a majority stake in the relevant state-owned telecommunication provider.[11] We also include two variables (one binary, one count) to address the presence as well as number of years since a country's retail telecommunications market has been open to competition between multiple service providers. We define this by the year in which competition in long-distance telephony first occurs.[12] Two variables addressing regulatory independence are also included, which measure the condition of separation and the number of years a country's telecommunication authority has been separated from direct political oversight. Finally, we include two variables to get at the issue of regulatory de-politicization, which occurs when a regulatory authority is judged to have become fully autonomous from the executive branch. In all policy variables, if a country had not yet implemented a particular policy reform in a given year, it received a score of zero. Those whose status is unknown are judged as missing.[13] For the years 1960–99, data were taken from Henisz, Zelner, and Guillen (2005) and for the years 2000–07 data were taken from the World Information Access Project (2007).

As a whole, this collection of data was 85% complete—quite good by standards in the field. While we did not impute any values for either the dependent variables or the independent variables of a policy nature, we used the *Amelia II* program created by Honaker, King, and Blackwell (2007) to impute missing values for the other independent variables.[14] The exception to this is with regard to our measure of GDP where we used linear interpolation to impute missing values (however, our data for GDP were overall 99% complete). In addition, since datum on adult literacy are patchy, if only a single year of data was provided we imputed this value for all years.

The averages of the imputed values from eight datasets were used to replace the missing data. Initially, the power consumption variable had the most missing data (67% complete) with FDI next in line (89% complete). All other variables were at least 95% complete. Appendices A and B offer the descriptive and correlational statistics for these variables.

5. EMPIRICAL MODELS

We utilized methods developed in time-series cross-sectional analysis to explore the determinants of a country's distribution of various ICTs over time. Unit heterogeneity is a concern in any estimating method, but especially important in time-series cross-sectional analysis. We chose a fixed effects model because there are features of the units of analysis (country-years) which are either unobservable or impossible to capture during the estimations, and both a Breusch and Pagan Lagrange multiplier test and Hausman specification confirmed the appropriateness of a fixed effects model.

We also confirmed the presence of first-order autocorrelation using a Wooldridge test. In order to correct this, we desired models that would account for dynamic specifications and certainly many have been presented in the methodological literature. Here, we chose to take two approaches so that the findings from one model can be verified with another using a slightly different specification. Initially, we estimated a model that uses a lagged dependent variable and includes a fixed effects specification to create the dynamic panel model that is addressed in Wilson and Butler (2007). This model takes the following form:

$$Y_{it} = \alpha_i + \beta X_{it} + \lambda Y_{it-1} + u_{it} \quad i = 1, \ldots, N \quad t = 1, \ldots, T,$$

where Y is a country's index of distribution of a particular ICT, i is an individual country, t is a period of time (1 year), α_i is the intercept, β is a scalar, X is the set of independent variables, λ is a scalar for the lagged dependent variable, and u_i is the unobservable unit effect.[15] However, including a lagged dependent variable may underestimate some of the effects of the independent variables, so we also ran a fixed effects model with a first-order auto regressive disturbance to adjust for auto correlation. This model takes the following form:

$$Y_{it} = \alpha_i + \beta X_{it} + u; \qquad u_{it} = \rho u_{it-1} + e_{it}$$
$$i = 1, \ldots, N \quad t = 1, \ldots, T,$$

where ρ is a scalar of the serial correlation parameter and e is the random error. Below, we present and discuss the results that emerge from both model specifications.

6. FINDINGS

Table 1 displays the regression results on indices of technology adoption. Of the statistically significant economic, demographic, and infrastructural variables, having large portions of the national economy generated by international trade is an important predictor of how much internet bandwidth that country has. Having a large trade economy is a negative predictor of computer adoption, and in the lagged model, of mobile phone adoption.

Population size, logged in these models, has a negative impact on the relative proportion of all technologies in a country—population size contributes positively to mobile phone penetration in the lagged dependent variable model, though not in the auto regressive model. Large urban populations have a small positive impact on mobile phone adoption in the auto regressive model, yet a small negative impact on the proportion of internet users. In other words, countries with more mobile phones than would be expected given their economic wealth have such high levels of adoption in part because of urbanization. This makes sense given that mobile phone connectivity is still relatively contingent on proximity to an urban center. In the auto regressive models, high levels of power consumption in the national economy also predict larger proportions of mobile phone and internet users. This also makes sense given that information technology use is predicated on a reasonably well-developed power infrastructure: this is one way a country's infrastructural investments can pay off in the long term. Telephone mainlines, a proxy for the strength of an existing (though older) information infrastructure, are a consistently positive predictor of internet use, computer adoption, and mobile phone adoption. This is consistent with other findings that disabuse the "leap-frog" metaphor: countries having made the public investments in an infrastructure of telephone landlines are more likely to have a good information infrastructure and user base today (Howard, 2007). Regime type only has a statistically significant impact on internet user base: being a more authoritarian regime clearly discourages internet use in the lagged model, though not in the more conservative auto regressive model.

Privatizing the national telecommunications provider does not seem to have, over time, a noticeably consistent impact on technology diffusion when other factors are held constant. Simply privatizing the provider has a slight positive impact on the proportion of hosts in a country, and over time this reform has a slight negative impact on mobile phone adoption. This may mean that holding all other factors constant, the sectoral restructuring around the privatized firm actually suppresses mobile phone adoption. The presence of liberalized consumer markets alone has a positive impact on the internet bandwidth available in a country. As time passes the continued health of competitive markets raises the proportion of internet hosts and personal computers according to both lagged and auto regressive models. However, controlling for other factors, in the auto regressive model for mobile phone diffusion each passing year of liberalized markets for consumer telecommunications services actually has a negative impact on the diffusion of mobile phones.

Regulatory separation is the only one of the four reform strategies with a fairly consistent, positive impact on technology diffusion: merely applying this strategy has a positive impact on computer and mobile phone adoption. In both the lagged and auto regressive models, each successive year of independence for the national telecommunications regulator improves a country's relative proportion of internet bandwidth and hosts. Each year of independence improves a country's proportion of computers according to the lagged model and mobile phones according to the auto regressive model. However, it has a negative impact in the lagged model for internet users.

Fully depoliticizing the national telecommunications regulator, however, has a fairly consistent negative impact on technology adoption. Merely applying this strategy has negative consequences for levels of internet bandwidth, hosts, computers, and mobile phones. The one positive impact of regulatory withdrawal appears as a tiny effect in the lagged model for mobile phones.

All in all, these findings confirm some conclusions found in more simple regression models, challenge others, and demonstrate the importance of policy reform strategies for encouraging ICT adoption. Surprisingly, this time-series cross-sectional

Table 1. *Determinants of the digital divide (154 countries, 1990–2007)*

	Internet bandwidth		Hosts		Users		Computers		Mobile phones	
	Lagged	AR (1)	Lagged	AR (1)	Lagged	AR (1)	Lagged	AR (1)	Lagged	AR (1)
Constant	39.263	−0.461	3.889**	8.793**	−1.105	0.468**	−0.549	−0.283	−3.562**	0.518**
	(12.364)	(0.237)	(1.253)	(1.176)	(1.347)	(0.029)	(1.065)	(0.162)	(0.809)	(0.133)
FDI	0.049	0.053	−0.011	0.005	0.013	0.002	0.038	0.036	0.002	0.007
	(0.143)	(0.147)	(0.030)	(0.031)	(0.028)	(0.030)	(0.023)	(0.023)	(0.019)	(0.019)
Trade	0.617**	0.467*	0.039	0.049	−0.024	0.048	−0.076**	−0.101**	−0.046*	−0.012
	(0.188)	(0.23)	(0.031)	(0.038)	(0.029)	(0.038)	(0.025)	(0.034)	(0.019)	(0.025)
Population[a]	−2.512**	0.248*	−0.225**	−0.508**	−0.002	−0.181**	0.003	−0.088**	0.172**	−0.500**
	(0.830)	(0.116)	(0.086)	(0.185)	(0.092)	(0.021)	(0.072)	(0.031)	(0.056)	(0.056)
Urban population	0.032	−0.005	0.000	−0.002	−0.004	−0.081**	−0.005	−0.011	−0.003	0.040**
	(0.019)	(0.018)	(0.003)	(0.007)	(0.003)	(0.003)	(0.003)	(0.006)	(0.002)	(0.009)
Literacy	0.000	0.000	−0.001	−0.001	0.000	−0.002	−0.001	−0.002	0.001	0.003
	(0.009)	(0.011)	(0.002)	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.003)
Power consumption[a]	0.040	−0.031	−0.007	−0.014	−0.027	0.037*	−0.005	0.037	−0.016	0.084**
	(0.123)	(0.129)	(0.021)	(0.027)	(0.018)	(0.019)	(0.020)	(0.026)	(0.013)	(0.019)
Telephone mainlines[a]	−0.127	−0.211	−0.014	−0.017	0.125**	0.239**	0.083**	0.206**	0.084**	0.344**
	(0.096)	(0.152)	(0.016)	(0.032)	(0.018)	(0.032)	(0.013)	(0.025)	(0.011)	(0.032)
Regime type	0.026	−0.070	−0.011	−0.019	−0.018*	−0.019	−0.006	−0.011	−0.003	−0.009
	(0.047)	(0.063)	(0.008)	(0.012)	(0.007)	(0.011)	(0.005)	(0.008)	(0.005)	(0.008)
Privatization (binary)	−0.009	−0.106	0.035*	0.034	0.004	0.012	0.020	0.018	0.010	0.023
	(0.117)	(0.169)	(0.017)	(0.027)	(0.014)	(0.022)	(0.011)	(0.016)	(0.011)	(0.019)
Years of privatization	−0.015	0.001	−0.002	0.005	0.002	0.010	−0.000	0.002	−0.004*	−0.004
	(0.018)	(0.031)	(0.003)	(0.005)	(0.002)	(0.005)	(0.002)	(0.004)	(0.002)	(0.006)
Market liberalization (binary)	0.165*	0.105	0.013	−0.003	0.006	0.020	0.003	0.007	−0.008	0.016
	(0.076)	(0.099)	(0.016)	(0.022)	(0.013)	(0.018)	(0.01)	(0.013)	(0.010)	(0.015)
Years of market liberalization	0.023	0.039	0.010**	0.022**	−0.003	−0.005	0.005*	0.013**	−0.002	−0.025**
	(0.016)	(0.026)	(0.003)	(0.006)	(0.002)	(0.006)	(0.002)	(0.004)	(0.002)	(0.006)
Regulatory separation (binary)	0.084	0.112	0.034	0.047	−0.005	0.028	0.022	0.036*	0.031**	0.077**
	(0.113)	(0.150)	(0.018)	(0.027)	(0.015)	(0.024)	(0.012)	(0.018)	(0.011)	(0.019)
Years of regulatory separation	0.072**	0.086**	0.012**	0.031**	−0.005*	0.006	−0.001	0.005	−0.002	0.038**
	(0.018)	(0.027)	(0.003)	(0.006)	(0.002)	(0.006)	(0.002)	(0.004)	(0.002)	(0.006)
Regulatory depoliticization (binary)	−0.439**	−0.492**	−0.051*	−0.065	−0.019	−0.055	−0.036*	−0.033	−0.027*	−0.060*
	(0.128)	(0.179)	(0.022)	(0.034)	(0.019)	(0.029)	(0.014)	(0.021)	(0.013)	(0.024)
Years of regulatory depoliticization	0.000	−0.068**	−0.001	−0.009	0.001	−0.009	0.000	−0.006	0.004*	−0.001
	(0.017)	(0.026)	(0.003)	(0.006)	(0.002)	(0.005)	(0.002)	(0.004)	(0.002)	(0.006)
Lagged DV	0.800**		0.664**		0.822**		0.728**		0.939**	
	(0.032)		(0.018)		(0.016)		(0.023)		(0.011)	
N	747	779	1,652	1,652	1,329	1,400	1,190	1,191	1,629	1,630
R^2	0.55	0.07	0.59	0.14	0.81	0.10	0.69	0.17	0.92	0.25

* $p < 0.05$.
** $p < 0.01$.
[a] Indicates the variable was logged in analysis.

study demonstrated no effect of FDI on technology diffusion. Similarly, literacy rates are not found to be statistically significant predictors, and while the literacy data required more imputations, this non-finding is consistent with other research. Several researchers have argued that regime type has an impact on the spread of many ICTs. But in the time-series cross-sectional regression, this effect washes out for four of the five technology indicators. Over time and holding other factors constant, only internet use suffers when regimes are more authoritarian.

Given these findings, we can demonstrate some of the effects of each of the four policy reforms on particular indicators of technology adoption in a country. Over time, international trade has a positive impact on a country's internet bandwidth. Population size has a positive impact on internet bandwidth in the lagged model, but the directionality of this effect reverses in the more conservative auto regression model. Internet bandwidth, holding other factors constant, tends to be higher for countries that have at least attempted to liberalize the consumer market for digital services and the more the time has passed since giving the telecommunications regulator some independence, the better. Fully withdrawing from public policy oversight of the communications sector, however, has a negative effect on the bandwidth available in countries over time. Indeed, in the auto regression model, the negative impact of regulatory withdrawal can overwhelm the positive impact of having an outward focused, trade-dependent economy. It is likely that market liberalization and some regulatory supervision create an encouraging environment for businesses to make the heavy investments needed to improve bandwidth, but that some leadership from the state is needed on when and where such investments should be made. For internet bandwidth, the negative effect of regulatory depoliticization deepens over time.

Yet for internet hosts, years of market liberalization and regulatory separation have a positive impact on the addition of new servers to the network. For information infrastructure, internet hosts are the one demonstrated beneficiary of

telecommunications privatization. Being a highly populated country where political leadership is withdrawn from the telecommunications sector, however, still negatively predicts internet hosting.

Countries with large populations are also likely to have fewer internet users than expected, even considering their relative wealth. In the more conservative auto regression model urban population is a negative predictor and power consumption a positive indicator, suggesting sensibly that over time the most energy intensive, slowly urbanizing economies draw in more internet users. Understandably, an existing landline infrastructure provides the largest, positive, statistically significant effects in the models for the global distribution of internet users. Interestingly, regime type is only statistically significant in predicting the number of internet users: suppressing political and civil liberties has a direct, negative impact on internet use. The common policy reform strategies have little impact on predicting levels of internet use: for seven of the indicators of policy reform, there is no observed statistically significant effect. In the lagged model separating the regulatory authority drives down the number of internet users.

International trade and having a large population drives down computer adoption, holding other factors constant, whereas having an existing landline infrastructure drives up computer adoption. Only market liberalization, regulatory separation, and regulatory depoliticization provide good explanations for the variation of computer distribution in this sample. The effect of the first two in predicting the number of computers is positive, the effect of the latter is negative. The more the years that consumer markets have to adjust to a liberalized regulatory regime independent of state interference, the better for computer adoption; yet more years of complete withdrawal of public policy oversight will hamper computer adoption.

Mobile phone adoption is depressed by levels of international trade. It is positively influenced by population size in the lagged model, but negatively influenced by population size in the more conservative auto regression model. And it is in this more conservative model that urban population and power consumption are found to have a positive impact. And, interestingly, the success of mobile phone technologies appears to be related to the quality of landline infrastructure, because having lots of telephone mainlines explain much about a country's share of the global supply of mobile phones. Controlling for other effects, years of privatized telecommunications are found to have a negative impact on the spread of mobile phones. And in this auto regression model liberalizing the consumer market for communications services also has a negative impact over time. For encouraging the development of mobile phone infrastructure, the best strategy—holding other factors constant—appears to be separating the regulator from direct control by the executive branch of government. Consistent with the other models of technology diffusion, too little public oversight has a negative impact on mobile phone adoption.

These models clarify some of the specific relationship between policy reform in the telecommunications sector and outcomes in technology diffusion. While the models confirm several findings that have emerged in the past research, there are some important new observations to be made. First, regime type is only observed as important in predicting levels of internet use, as Milner and Howard have found, but it is not observed in models of other forms of technology diffusion. Holding other factors constant, regime type explains the global distribution of internet users, but only the policy reform strategies have a demonstrable effect on other indicators of global ICT adoption.

Second, in time-series analysis, combinations of public policy reforms are revealed to be very important in explaining whether a country has more or less technology than expected given their economic wealth. The impact of privatization is only confirmed in relation to internet hosts and mobile phone adoption, and the relationship is positive in the former and negative in the latter. In other words, holding other factors constant, selling a controlling stake in the national telephone company has a differentiated impact. It should be noted, moreover, that in none of the conservative auto regression models was privatization found to have a statistically significant effect on technology adoption. Market liberalization is a largely constructive policy that encourages investment in internet bandwidth, the addition of more internet hosts to the national internet infrastructure, and the purchase of more computers, with the caveat of a slight negative effect on the adoption of mobile phones and no observed impact on the level of internet use. Giving the regulatory authority formal independence from the head of state is a largely constructive policy with demonstrated, positive effects on all but internet use. However, it may be that full depoliticization results in too little public oversight, leaving the agency unable to effectively regulate or take initiative in developing information infrastructure. This policy reform is a largely regressive policy with demonstrated, negative effects on all but mobile phone adoption, where there is a very small, positive effect.

Third, this time-series treatment is interesting in that several expected effects are unobserved. Integration into the global economy in terms of foreign direct investment is not a statistically significant predictor of technology diffusion. Ties to the global economy might explain technology adoption in particular countries, but this relationship was not observed globally over an extended period. Similarly, levels of adult literacy do not have an observed impact on technology diffusion, even though some researchers have hypothesized a connection between literacy and internet use.

Hence, we conclude that the particular way in which the telecommunications sector is reformed has an effect on the extent to which a country can develop its digital information infrastructure and user base. In other reform sectors there is also evidence that the sequencing of reforms is key. For example, a study of 25 countries revealed that regulatory independence should precede the privatization of electricity providers (Zhang, Parker, & Kirkpatrick, 2005). As a strategy for reforming the telecommunications sector, however, privatization alone is not observed to have a robust impact on technology diffusion. Indeed, in many countries the national telecommunications provider was also the regulator, so the institutional innovation of separating the regulator may be important because doing so effectively created an organization dedicated to managing the public spectrum (Gutierrez & Berg, 2000).

7. CONCLUSION

This analysis advances our understanding of the causes of the digital divide in a number of ways. While several researchers have used basic regression analysis to expose the relationship between regime type, perception of the business environment, and technology adoption, we demonstrated a more specific relationship between public policy initiatives and technology use outcomes in a way that holds theoretically important variables, including time, constant. Holding other factors constant, separating the industry regulator from the executive branch of government and ending the direct reporting relationship has

the best outcome in terms of technology adoption. The findings suggest that some public supervision of the telecommunications sector—perhaps by a professional bureaucracy rather than elected politicians—may be a positive step toward narrowing the digital divide. Full depoliticization and deregulation of the telecommunications sector usually have a negative impact on the diffusion of information technologies, and a country's share of the global supply of internet bandwidth, users and computers may not even be affected by whether or not the state owns a controlling interest in the national phone company.

Instead of taking the traditional perspective on the worldwide spread of information and communication technologies, usually measured by rates of *per capita* diffusion, we take a distributional perspective and offer a way of measuring each country's relative portion of the global supply of ICTs. In part, this has meant focusing on change in the digital divide, not simply on its magnitude at a single point in time. In addition, this study indexes technology distribution with weights for economic wealth, something recommended by the literature but not regularly done (Corrales & Westhoff, 2006; Fink & Kenny, 2006; Howard, 2007). Additionally, our models distinguish between the impact of attempting policy reforms such as privatization and the long-term impact as markets adjust and new institutional arrangements take shape after formal privatization is concluded.

Why would regulatory independence mitigate the digital divide, but too much depoliticization and deregulation exacerbate it? It is likely that all other things being equal, the best policy environment for the telecommunications sector is a balanced environment maintained by an independent regulator, but one that is not above representing the public interest or entering into public private partnerships to develop national information infrastructure. Moreover, the lack of a widely observable impact for privatization may lie in the degree to which the public interest in the telecommunications provider is sold off. Here, we set the threshold at having the government selling its simple majority, controlling interest in the national phone company. Future research could test the possibility that the impact of retaining a large minority control may be different from complete divestment. Additionally, there are almost certainly degrees of market liberalization, which could be measured as the number of effective competitors for providing consumer services. Finally, it is possible that the effects of these policy reforms take more than 17 years to become positive.

To be sure, there are advantages and disadvantages in working with this kind of policy data. The four types of policy reforms are somewhat generalized as there are often local variations in reform in particular countries. In some countries, privatization has involved selling the publicly developed infrastructure and opening up market competition in many parts of the telecommunication sector, leading to more affordable computers and mobile phones and thus greater internet use. In others, however, privatization has involved creating privately held monopolies, with owners who are indistinguishable from political elites. Countries also often combine policy tools, and there are certainly alternatives to the four that we analyze here. Still, the four policy reform types included in this study are the mostly commonly used forms of policy intervention in the telecommunication sector and they are also the ones most promoted by multilateral lending institutions.

There are stark contrasts in the level of technology access around the world, and our findings suggest that some policy reforms can exacerbate the digital divide while others alleviate it. Controlling for economic, demographic, political, and infrastructural factors, we found that the four most common policy reform strategies have quite different effects on the distribution of information technologies. Indeed, the mix of reforms needed to close the digital divide is likely to be both complex and contingent on the particular way that these reforms are implemented. But to build a strong information infrastructure for social development, the state should not completely withdraw from public leadership in the development of communications infrastructure.

These findings demonstrate that neither blanket state-directed or private sector-directed approaches to technology diffusion will work in isolation. Instead, a role for the state alongside the private sector appears to be the best recommendation that emerges from this study. Although subsequent analysis of the influence that these policy-related factors have on a country's share of all ICTs certainly needs to be undertaken, what we have presented in this article is an important step toward understanding how policy reform can impact inequality in the global distribution of digital telecommunications.

NOTES

1. The ICT diffusion research often uses data on the rate at which new technologies are taken up in a country, compares these adoption rates with neighboring countries or previous points in time, and assumes that the pattern of technology adoption within a country will follow an *S*-curve pattern (Rogers, 2003; UNCTAD, 2006). In contrast, the ICT distribution research often works with data on the relative share of global infrastructure available in a country, comparing changes in the proportional supply of global ICT infrastructure over time, and assumes that technology adoption patterns within non-OECD countries rarely, if ever, follow an *S*-curve pattern (Barzilai-Nahon, 2006; Howard, 2007).

2. Though studies have been done on personal computers, few have addressed the spread of mobile phones. One important exception is Cartier, Castells, and Qiu's (2005) analysis of mobile phones in China.

3. Indeed, it is also important to recognize that one important source of the digital divide is reflected in the variation in the speed of internet access given that people living in advanced industrial economies have more affordable broadband access than those on the other side of the developmental spectrum. High quality comparative, long-term data on broadband access across multiple countries are as yet unavailable.

4. There is a great difference in English competence and computer skill sets between populations throughout the world. This is sometimes labeled a "second order" digital divide, though it has been difficult to demonstrate its impact across countries.

5. Despite the salience of their findings, it might be noted that one limitation when applying results from Dedrick *et al.* (2003) and Pohjola (2003), to the current day is that they cover a time period before most of the digital infrastructure arrived in developing countries as well as before the dot-com crash.

6. We use GDP PPP in constant 2005 international dollars from the World Development Indicators dataset.

7. GDP alone is an indicator of economic size rather than wealth, so the models control for population size.

8. Estimates of internet users are from the subscription rates reported by in-country internet service providers, rates that might not reflect the actual number of people using shared internet access points (Miller & Slater, 2000). The number of reported internet users may be underestimated in poor countries where multiple users will share computers belonging to friends and family, a library, or cybercafé.

9. In many countries, the cost of a personal computer is higher than the average annual income. The number of personal computers may underestimate the total use of computers, especially where computers are a shared resource, and such a value does not reveal the great differences in the quality of computers. The number of personal computers underestimates the use of computers in countries where mainframe computers are prevalent and where computers are a collective, not personal resource. A count of the number of personal computers may exclude networked gaming systems and other information technologies.

10. Initial tests used *Polity IV* with similar results, but *Freedom in the World* data offered more cases.

11. There were no cases of telecommunications provider nationalization during the time frame of this study.

12. These definitions and data of 1999 come from Henisz, Zelner, and Guillen (2005). Data on additional countries covering the period 1999–2004 were collected by hand and are available from the authors.

13. Using both the binary and count measures in the regressions does not introduce problems with multicollinearity (also see Appendix B). When both are included the Variance Inflation Factor (VIF) increases marginally and is well below 4.0, which is generally considered the threshold for multicollinearity.

14. See Honaker *et al.* (2007). "Amelia II" is available at: http://gking.harvard.edu/amelia/.

15. There is some initial concern in using this model because its least-squares estimates have been shown to be both biased and inconsistent. While there are many available specifications that can correct for this bias, they necessitate an asymptotic N, which is not present in this study. Fortunately, Wilson and Butler report Monte Carlo results indicating that the overall bias would be low for this type of study, though still high when estimating the coefficient for the lagged dependent variable (i.e., λ). Given that this value is of little concern here, we have chosen to adopt the dynamic panel model as one of the estimation models for this study (Judson & Owen, 1999; Wilson & Butler, 2007).

REFERENCES

Acemoglu, D., & Robinson, J. (2000). Political losers as barriers to economic development. *American Economic Review: Papers and Proceedings, 90*(2), 126–130.

Barzilai-Nahon, K. (2006). Gaps and bits: Conceptualizing measurements for the digital divide/s. *The Information Society, 22*(5), 269–278.

Bauer, J., & Maitland, C. (2002). Internet access in the European Union and the United States. *Telematics and Informatics, 19*(2), 117–137.

Beilock, R., & Dimitrova, D. (2003). An exploratory model of inter-country internet diffusion. *Telecommunications Policy, 27*, 237–252.

Boas, T., Dunning, T., & Bussell, J. (2005). Will the digital revolution revolutionize development? Drawing together the debate. *Studies in Comparative International Development, 40*(2), 95–110.

Cartier, C., Castells, M., & Qiu, J. L. (2005). The information Have-Less: Inequality, mobility, and translocal networks in Chinese cities. *Studies in Comparative International Development, 40*(2), 9–34.

Caselli, F., & Coleman, W. J. (2001). *Cross-country technology diffusion: The case of computers*. Cambridge: National Bureau of Economic Research.

Chase, M. S., & Mulvenon, J. C. (2002). *You've got dissent: Chinese dissident use of the internet and Beijing's counter-strategies*. Santa Monica, CA: RAND Corporation.

Chinn, M. D., & Fairlie, R. W. (2004). *The determinants of the global digital divide: A cross-country analysis of computer and internet penetration*. Madison, WI: University of Wisconsin Social Systems Research Institute.

Corrales, J., & Westhoff, F. (2006). Information technology adoption and political regimes. *International Studies Quarterly, 50*(4), 911–933.

Dedrick, J., Gurbaxani, V., & Kraemer, K. (2003). Information technology and economic performance: A critical review of empirical evidence. *ACM Computing Surveys, 35*(1), 1–28.

Diebert, R. (2008). The geopolitics of internet control. In A. Chadwick, & P. N. Howard (Eds.), *The handbook of internet politics*. London, UK: Routledge.

Dutta, S., & Lopez-Claros, A. (2005). *The global information technology report, 2004–2005: Efficiency in an increasingly connected world*. New York: Palgrave Macmillan/INSEAD.

Evans, P. (2005). The new commons vs. the second enclosure movement: Comments on an emerging agenda for development research. *Studies in Comparative International Development, 40*(2), 85–94.

Fink, C., & Kenny, C. (2006). W(h)ither the digital divide?. *Info, 5*(6), 15–24.

Fischer, C. S. (1992). *America calling: A social history of the telephone to 1940*. Berkeley, CA: University of California Press.

Freedom House (2008). *Freedom in the world dataset 2008*. Cited 11.01.08.

Goolsbee, A., & Klenow, P. (2002). Evidence on learning and network externalities in the diffusion of home computers. *Journal of Law and Economics, 45*(2), 317–343.

Guillén, M., & Suarez, S. (2005). Explaining the global digital divide: Economic, political and sociological drivers of cross-national internet use. *Social Forces, 84*(2), 681–708.

Gutierrez, L. H. (2003). Regulatory governance in the Latin American Telecommunications Sector. *Utilities Policy, 11*(4), 225–240.

Gutierrez, L. H., & Berg, S. (2000). Telecommunications liberalization and regulatory governance: Lessons from Latin America. *Telecommunications Policy, 24*(10–11), 865–884.

Henisz, W., Zelner, B., & Guillen, M. (2005). The worldwide diffusion of market-oriented infrastructure reform, 1977–1999. *American Sociological Review, 70*(6), 871–897.

Honaker, J., King, G., & Blackwell, M. (2007). *Amelia II: A program for missing data*. Version 1.2-0, April 9, 2009.

Howard, P., Busch, L., Nafus, D., & Anderson, K. (2009). Sizing up information societies—Towards a better metric for the cultures of ICT adoption. *The Information Society, 25*(3).

Howard, P. N. (2007). Testing the leap-frog hypothesis: Assessing the impact of extant infrastructure and telecommunication policy on the global digital divide. *Information, Communication & Society, 10*(2), 133–157.

Howard, P. N., Busch, L., & Cohen, S. (2008). ICT diffusion and distribution dataset, 1990–2007. *ICPSR Public Dataset #9908*.

Howard, P. N., & World Information Access Project (2007). *WIA report 2007 – Wired states*. Seattle, WA: University of Washington.

Hughes, T. P. (1983). *Networks of power: Electrification in western society, 1880–1930*. Baltimore, MD: Johns Hopkins University Press.

ISC (2008). *Domain name survey*. Internet Systems Consortium, Inc. Cited 11.01.08. <http://www.isc.org/index.pl?/ops/ds/>.

ITU (2008). *World telecommunication indicators database*. International Telecommunication Union 2008. Cited 11.01.08. <http://www.i-tu.org>.

Johnson, E., & McGlinchey, E. (2005). Digital divide in Central Asia: Comparing I.S.P. Policy. In *Paper read at annual conference of the Midwest Political Science Association, Chicago, IL*.

Judson, R. A., & Owen, A. L. (1999). Estimating dynamic panel data models: A guide for macroeconomists. *Economic Letters, 65*, 9–15.

Kalathil, S., & Boas, T. (2003). *Open networks, closed regimes: The impact of the internet on authoritarian rule*. Washington, DC: Carnegie Endowment for International Peace.

Kaushik, P. D., & Singh, Nirvikar (2004). Information technology and broad-based development: Preliminary lessons from North India. *World Development, 32*(4), 591–607.

Kiiski, S., & Pohjola, M. (2002). Cross-country diffusion of the internet. *Information Economics and Policy, 14*(2), 297–310.

Li, W., Zhen-Wei Qiang, C., & Colin Xu, L. (2005). Regulatory reforms in the telecommunications sector in developing countries: The role of democracy and private interests. *World Development, 33*(8), 1307–1324.

Mann, C. L., & Rosen, D. (2002). *The new economy and A.P.E.C.* Washington, DC: Peterson Institute for International Economics.

Miller, D., & Slater, D. (2000). *The internet: An ethnographic approach*. New York: Berg Publishers.

Milner, H. (2006). The digital divide: The role of political institutions in technology diffusion. *Comparative Political Studies, 39*(2), 176–199.

Noll, R. G. (2000). Telecommunications reform in developing countries. In A. O. Krueger (Ed.), *Economic policy reform: The second wave*. Chicago, IL: University of Chicago Press.

Norris, P. (2001). *Digital divide: Civic engagement, information poverty, and the internet worldwide*. New York: Cambridge University Press.

Oxley, J., & Yeung, B. (2001). E-commerce readiness: Institutional environment and international competitiveness. *Journal of International Business Studies, 32*, 705–723.

Parente, S. L., & Prescott, E. C. (1994). Barriers to technology adoption and development. *Journal of Political Economy, CII*, 298–321.

Pohjola, M. (2003). The adoption and diffusion of ICT across countries: Patterns and determinants. In D. C. Jones (Ed.), *The new economy handbook*. New York: Elsevier Press.

Quibria, M. G. (2002). *Digital divide: Determinants and policies with special reference to Asia*. Manila: Asian Development Bank.

Rogers, E. M. (2003). *Diffusion of innovations* (Vol. 5). New York: Free Press.

UNCTAD (2006). *The digital divide report: ICT diffusion index 2005*. New York and Geneva: United Nations.

UNCTAD (2008). *Handbook of statistics*. Geneva: UNCTAD.

Volken, T. (2002). Elements of trust: The cultural dimension of internet diffusion revisited. *Electronic Journal of Sociology, 6*(4), 1–20.

Wallsten, S. (2005). Regulation and internet use in developing countries. *Economic Development and Cultural Change, 53*, 501–523.

Weber, S., & Bussell, J. (2005). Will information technology reshape the North–South asymmetry of power in the global political economy?. *Studies in Comparative International Development, 40*(2), 62–84.

Wilson, S. E., & Butler, D. M. (2007). A lot more to do: The sensitivity of time-series cross-section analyses to simple alternative specifications. *Political Analysis, 15*(2), 101–123.

World Bank (2008). *World Bank development indicators*. Cited 11.01.08. <http://www.worldbank.com>.

World Economic Forum (2002). *The global information technology report*. New York: Oxford University Press.

Zhang, Y., Parker, D., & Kirkpatrick, C. (2005). Competition, regulation and privatisation of electricity generation in developing countries: Does the sequencing of the reforms matter?. *The Quarterly Review of Economics and Finance, 45*(2–3), 358–379.

APPENDIX A. DESCRIPTIVE STATISTICS

Variable	Mean	Std. dev.	Minimum	Maximum
Dependent variables				
Internet bandwidth	0.524	0.870	0.000	8.440
Internet hosts	0.221	0.435	0.000	3.429
Internet users	0.470	0.390	0.000	2.002
Personal computers	0.556	0.328	0.014	1.775
Mobile phones	0.498	0.441	0.000	2.300
Independent variables				
GDP	24.239	2.248	18.117	30.196
FDI	0.052	0.203	−0.829	5.22
Trade	0.829	0.461	0.108	4.625
Urban population	52.067	23.024	5.400	100.000
Population	15.754	1.931	10.600	21.001
Literacy	80.324	21.529	12.221	99.8
Power consumption	7.506	1.416	2.916	10.248
Regime type	3.366	1.865	1.00	7.00
Telephone mainlines	13.004	2.457	7.090	19.723
Independent variables (policy variables)				
Privatization (binary)	0.388	0.487	0	1
Years of privatization	4.803	10.141	0	47
Market liberalization (binary)	0.423	0.494	0	1
Years of market liberalization	3.380	7.396	0	45
Regulatory separation (binary)	0.549	0.498	0	1
Years of regulatory separation	0.580	4.889	0	28
Regulatory depoliticization (binary)	0.312	0.463	0	1
Years of regulatory depoliticization	0.414	5.981	0	47

APPENDIX B. CORRELATION MATRIX, INDEPENDENT VARIABLES

	FDI	Trade	Population	Urban population	Literacy	Power consumption	Telephone mainlines	Regime type	GDP	Privatization (binary)	Years of privatization	Market liberalization (binary)	Years of market liberalization	Regulatory separation (binary)	Years of regulatory separation	Regulatory depoliticization (binary)	Years of regulatory depoliticization
FDI	1.00																
Trade	0.36	1.00															
Population	−0.19	−0.43	1.00														
Urban population	0.12	0.13	0.03	1.00													
Literacy	0.10	0.17	−0.11	0.60	1.00												
Power consumption	0.14	0.21	−0.31	0.53	0.61	1.00											
Telephone mainlines	−0.03	−0.15	0.73	0.07	0.13	0.04	1.00										
Regime type	−0.11	−0.07	0.27	−0.40	−0.49	−0.47	0.05	1.00									
GDP	−0.08	−0.26	0.84	0.44	0.27	0.13	0.83	−0.08	1.00								
Privatization (binary)	−0.03	0.03	0.01	0.22	0.10	0.09	0.02	−0.35	0.11	1.00							
Years of privatization	−0.03	0.04	−0.10	0.16	0.08	0.13	0.01	−0.29	0.00	0.60	1.00						
Market liberalization (binary)	0.06	0.03	0.20	0.17	0.12	0.14	0.15	−0.26	0.30	0.46	0.36	1.00					
Years of market liberalization	0.00	0.05	0.05	0.08	0.04	0.10	0.18	−0.21	0.15	0.4	0.65	0.57	1.00				
Regulatory separation (binary)	0.04	0.08	0.06	0.15	0.05	0.09	−0.02	−0.32	0.15	0.44	0.24	0.44	0.24	1.00			
Years of regulatory separation	0.01	0.06	0.08	0.20	0.12	0.13	−0.08	−0.33	0.19	0.54	0.41	0.49	0.40	0.66	1.00		
Regulatory depoliticization (binary)	0.09	0.11	0.02	0.05	−0.11	−0.02	−0.01	−0.17	0.07	0.28	0.09	0.41	0.26	0.59	0.37	1.00	
Years of regulatory depoliticization	0.06	0.09	−0.09	−0.03	−0.08	0.04	−0.04	−0.15	−0.06	0.29	0.14	0.23	0.23	0.37	0.46	0.62	1.00