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Post-industrial transformations and cyber-space: a cross-national analysis of Internet development

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Abstract

At century's end, a combination of telecommunications and computer technologies has resulted in the creation of the Internet, a global network of computers that has been growing at an exponential rate. Although the Internet/World Wide Web combination is widely hailed as a new, powerful engine of global social and economic change, there has been very little sociological theorizing and even less sociological research on the globalization of the Internet. Using classical macrosocial theories of development as a springboard, we hypothesize that the level of development, political openness/democracy, mass education, the presence of a sizeable tertiary/services sector, and interactions between some of these variables will drive the Internet's growth and spread around the globe. In our cross-national analysis of approximately 74 developed and developing countries, we find that Internet capacity is not in fact a simple linear function of economic and political development, but rather has been driven by complex interactions that could aptly be termed "post-industrialism." Uncovering some of these structural preconditions and determinants of Internet diffusion provides a first step toward providing a theoretical and empirical sociology of this "third technological revolution." © 2002 Elsevier Science (USA). All rights reserved.

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1. Introduction

The Internet's sociological relevance follows on both pragmatic and theoretical grounds. The economic importance of new information technologies to "post-industrial" nations can hardly be overestimated, given that on average over half of economic production in OECD countries is generated by knowledge-based industries. The social impact of Internet usage is no less important, with increasing attention being paid to social inequalities in usage, the urban morphological changes attendant on telecommuting, global homogenization of national cultures, the social isolation/loss of community encouraged by web "surfing," and shifts in social organization brought about by the "electronic cottage" (Marien, 1996; Mitchell, 1995; Schiller, 1992; Slouka, 1995; Toffler, 1980; United Nations, 1999, pp. 57–76).

The global spread of the Internet also holds important theoretical ramifications. In essence, the theories that shape our current understanding of society were forged in the industrial crucible of the 19th century. Whether we are discussing Durkheim's (1893) organic and mechanical solidarities, Tonnies' (1963) *gemeinschaft* and *gesellschaft*, Marx' industrial capitalism ([1867] 1967) or more contemporary notions such as modernization theory's "logic of industrialism" (Kerr et al., 1960), the abilities of current macrosocial theories to shape future social thought are challenged by what Daniel Bell (1989) has called "the third technological revolution." In discussing this post-industrial revolution, Bell (1973) argues that post-industrial societies are dominated by large information-driven economies run by a new class of technically and scientifically skilled workers who manipulate and process theoretical knowledge for the formation and maintenance of social and economic production and policy. Fundamental to Bell's analysis is the dissemination of information as the fulcrum for social processes in the post-industrial society. Certainly the post-industrial society retains elements of *gesellschaft*, such as complex networks of instrumental relations, but these become extended and reshaped via an entirely new media—*telecommunications technology*. Information-sharing becomes the major form of economic and social sustenance for large segments of post-industrial populations. Given the rapid formation of global interdependencies and web of communication networks devoted to innovation, information-sharing, coordination and control, it is likely that the world is verging on another revolution as profound as the industrial transformation of the last century.

Despite these important implications, non-academic analysts have been far more attentive to this budding revolution than have sociologists. Their discussions are often organized around the new global economy, however defined, and how information oils the gears of this new production system. Unfortunately, these analyses generally lack a deeper understanding of sociological processes. The purpose of this article is therefore to determine if

current theories used in macrosociology are capable of gaining purchase on the current cross-national distribution of Internet development. In our cross-national analysis of approximately 74 countries, we find that adoption of the Internet has not been a simple linear function of economic and political development, but instead has been driven by complex interactions involving different structural dimensions that could be termed “post-industrialism.” By uncovering some of these structural preconditions and determinants of Internet diffusion and adoption we take a first step toward providing a theoretical and empirical sociology of this revolutionary new phenomenon.

2. The Internet: growth and importance

While the Internet has received little sociological treatment from a cross-national perspective, what has been accomplished provides an important opportunity to examine this phenomenon. At least one organization, Network Wizards (2001),¹ keeps statistics about the relative distribution of Internet *hosts*² cross-nationally—data which can now also be obtained from the World Bank. Counting the number of Internet hosts is one way to quantify the Internet, although one must remember that the number of hosts does not indicate the number of users or the quality of usage. The most current Internet host tally (January 2001) suggests that the number of Internet hosts stands at approximately 110 million around the world. This figure is substantially higher than the count in the early 1980s when the study began. The NUA compiles approximate statistics on the number of worldwide users of the Internet. As of December 2000, they estimated approximately 418 million people use the Internet worldwide (NUA, 2001). The Internet and WWW are continually growing, according to these results.

In addition to this exponential growth, sociologists are interested in the social and economic impacts of Internet development. Socially and culturally, the advertisement of cultural products and therefore the diffusion of cultural traits promise to increase in political significance for developing

¹ Network wizards collects data through a networking program that “pings” Internet hosts around the globe for numeric responses. The signal returns with approximated number of hosts per host category (top-level domain name).

² “On the Internet, the term ‘host’ means any computer that has full two-way access to other computers on the Internet. A host has a specific ‘local or host number’ that, together with the network number, forms its unique Internet Protocol address. If you use PPP to get access to your access provider, you have a unique IP address for the duration of any connection you make to the Internet and your computer is a host for that period. In this context, a ‘host’ is a node in a network.” (*whatis.com* definition).

nations (Danowitz et al., 1995; Drake, 1995; Targowski, 1996). Since the Internet is predominantly Western and Anglophone, the potential for one-sided cultural diffusion is high (Hedley, 1998), and the consumption of goods and services over the Internet may come to represent status as much as commerce, particularly in developing countries.

Telecommunications researchers note that economic underdevelopment is correlated with telecommunications underdevelopment (Danowitz et al., 1995; Saunders et al., 1994). Jussawalla and Meheroo (1980) observes that corporations (MNCs) bring telecommunications to the developing world and thus have the potential for stimulating market demand and economic growth. A few studies of developing countries find that areas with high levels of resources and skilled labor but with lower levels of telephony have fewer “productive enterprises” (Kayani and Dymond, 1997). Telecommunications infrastructures also enable better development of agricultural and natural resources and manufacturing, thereby increasing “self-sufficiency and export growth” (Hufbauer, 1996; Kiplagat and Werner, 1994). Additionally, telecommunications technology allows for social and economic diffusion and consequently regional integration in certain third world hinterlands (Alonso, 1980; Wellenius, 1977).

As market shares increase in international scope and corporations become global, the need for information increases. A reliable and competitive telecommunications structure will, in turn, encourage investment by multinational corporations (Hudson, 1997; Sauvart, 1983), which further encourages global trade and network formation (Drake, 1995; World Bank, 1998; Kiplagat and Werner, 1994).

Although a fairly comprehensive empirical literature on telephony exists, much less research comprehensively examines the modern Internet and related computer networks. What little exists focuses on Internet concentration and connectivity among OECD countries or within the United States. Hargittai (1999) finds that economic wealth and telecommunications policy are important for Internet development in OECD nations. Within the United States, Moss and Townsend (1998) conduct a spatial-economic analysis of inter-metropolitan Internet concentration and traffic flows. They find that areas that are substantially less urbanized, economically and socially depressed cities, and a few other regions with less information-intensive industries and infrastructure fall behind the rest of the nation in Internet concentration. Additionally, Wheeler and O’Kelly (1999) perform an analysis of Internet connectivity within the United States. Their results indicate a hierarchy of cities based on the number of connections to other cities directly serviced by the sampled Internet “backbones.” Those cities that have been historically important in national transportation networks and information flows are at the top of the accessibility list, suggesting that both infrastructure and occupational differentiation are important precursors of accessibility (e.g., New York, Chicago, and Dallas).

Generally speaking, telecommunications play key roles in economic and social life in the modern world and increasingly in the developing world. Given its importance in a rapidly globalizing economy, the development and concentration of the Internet are worth investigating. Pursuant to this, our goal in this research is to identify those social structural factors that predict the level of Internet development/concentration across nations, with the ultimate aim of understanding how the Internet is likely to spread across the globe in the near future. Secondly, we hope to demonstrate the usefulness of extant macrosocial theories in predicting the likely pattern of Internet diffusion and usage.

3. Sociological theory and the diffusion of the Internet

Given that few studies of the Internet explicitly tap into sociological theory, the main purpose of our analysis is to use macrosocial theories to shed light on the international diffusion of the Internet and, perhaps along the way, begin to address the need for structural theories of post-industrial societies. Fortunately, we are guided by some preliminary research detailing the diffusion of the Internet by the *Mosaic Group*, a research affiliation with the Information Sciences program at the University of Arizona (Goodman et al., 1994; The Mosaic Group, 1998). In their current speculations into the processes and determinants of the global Internet diffusion, they specify a number of variables that influence the spread of computer telecommunications: prior development of telecommunications infrastructure, personal computing and software, financial resources, human capital, sectoral demand and awareness, and a competitive environment. Translated into the concerns of development theory and macrosociology, most of these variables can be subsumed under a modernization and/or diffusion umbrella. Supplemented by political economy (Dependency/World System Theories), a fairly parsimonious account of Internet diffusion emerges.

3.1. *Economic and infrastructural development*

Modernization theory suggests that the economic and social development of a nation is due to internal and evolutionary characteristics of the nation itself. Certain internal characteristics such as the availability of a market for investment and output are necessary before a nation can engage in the “take off stage toward industrialization (Rostow, 1990). Additionally, some thresholds of infrastructural development are necessary to proceed to later stages of economic development (Alonso, 1980; Rostow, 1990), as well as investments in research and development. Indeed, as Spencer (1898, 1876, pp. 509–512) first noted, the more complex the society the greater the ratio of information to material resources. Therefore, industrialized societies have

a greater need for adequate transportation and telecommunications over less developed societies mainly because access to information and the ability to disseminate information are increasingly crucial for complex interdependent social systems—an environment ripe for Internet adoption.

As cases in point, Danowitz et al. (1995) researched the barriers to Internet growth in five North African countries (Egypt, Tunisia, Algeria, Libya, and Morocco). A few of these structural barriers were slower growth of incomes and failure to develop the necessary degree of consumption, lack of regional, social, and economic integration, low teledensity infrastructure, and an unabsorbed labor surplus.

Probably the major mediator between development level and Internet diffusion is the prior existence of telephone mainlines, given that connectivity is overwhelmingly dependent on telephone infrastructure. Presently, much of the non-sociological work on the diffusion of the Internet concurs with the need for a high degree of telephone mainlines per capita (Bazar et al., 1998; Goodman et al., 1994; Hadi Salim, 1995; Press, 1995; The Mosaic Group, 1998; Wheeler and O’Kelly, 1999). Sadly, over 25 percent of the world’s nations have not yet reached a teledensity of one, meaning that countries like Kenya and Cambodia do not even have one telephone for every 100 people in their populations (United Nations, 1999). So, in addition to the level of development and all it entails, simple infrastructure will constitute an insurmountable “proximate determinant” in Internet diffusion, at least so long as current technological constraints remain unchanged.

3.2. Political openness

A political institution that is open to different internal political and social input from its citizenry is probably more likely to embrace a diversified, information-diffusing and hence individually empowering technology like the Internet. As Buchner (1988) noted, formerly Marxist states demonstrated a very strong preference for television diffusion over telephone diffusion, at least in comparison to non-Marxist nations. The fundamental reason behind this preference was the perception that the telephone threatens established political monopolies by (1) promoting the spread of ideas counter to the party line, and (2) spreading information across national borders that might prove embarrassing or threatening to the regime in power. Just as importantly, telephone communication is notoriously difficult to control and expensive to monitor (Buchner, 1988). Consistent with these ideas, Buchner found that while the diffusion of televisions remained fairly uniform across societies, the telephone diffused more rapidly and thoroughly in non-Marxist states. Because the telephone allows individuals and private groups greater freedom to communicate and thus to coordinate activities independently of the state, Marxist states tended to prevent the diffusion of two-way flow technologies such as the telephone.

Extending this logic, more politically open nations will accept Internet technology since it can serve as an important link to political mobilization and global economic opportunity. Modernization theory suggests that politically open societies are generally more accepting of technology because such societies enjoy competitiveness in both economics and politics, and the diffusion of technologies enrich these competitive processes. From a political economic perspective, more open nations encourage larger concentrations of transnational corporations who import their own telecommunications technology, thus paving the way for computerization and communication with core nations.

Alternatively, more open or democratic societies usually embrace the notions of private property, investment and individual consumerism, meaning that they are less likely to closely regulate or restrict their civic societies. Governments that are overly concerned with security issues or harbor unsympathetic or inept policies that “pre-empt bandwidth” for their own purposes can destroy the Internet’s potential for a nation. Thus, political freedom is a likely requirement for mass diffusion of the Internet.

3.3. *Modernizing institutions: education*

If education is the “handmaiden of industrialism” (Kerr et al., 1960), then it becomes post-industrialism’s “woman of the house.” Two arguments can be made about the influence of education on post-industrial development, one microsocial and the other macrosocial.

At the microsocial level, educated people use resources more cleverly, are more productive on the job because they have greater facility with productive technologies (like the Internet), and make more intelligent consumers, forcing product quality ever upward. An educated work force reduces training costs while at the same time allowing an accelerated pace of technological change in the workplace. These microsocial accounts can be lumped under *human capital theory* (Becker, 1964; Schultz, 1961).

Furthermore, the macrosocial effects of mass education warrant attention. Most of the theoretical mechanisms posited by structural modernization theorists are conditioned by the level of formal schooling in a population. For instance, some theorists hypothesize that economic change will be most rapid from low to intermediate levels of development because improvements in labor productivity peak as workers are reallocated from subsistence agriculture to urban/industrial employment. Mass education accelerates this structural transition by (1) ‘lubricating’ the movement of workers between sectors by providing them with the necessary skills and attitudes; and (2) encouraging rapid rural-to-urban migration as literate agricultural workers seek better lives in the city. As a simple extension of this logic, the demand for computers and on-line skills will be driven in part by the degree of education in the population.

More importantly, mass education lays the groundwork for rapid *diffusion* of material and non-material artifacts (Rogers, 1995, pp. 271–311). By providing populations with a unifying language and cultural heritage, national education systems may promote greater national cohesion. Moreover, literacy and basic technical education allow for more rapid innovation-diffusion than would otherwise be the case, and secular attitudes gained in schools would reduce hidebound opposition to social change. On a more abstract level, the presence of educational institutions suggests cultural and institutional convergence with the West on development issues like the uses of telecommunications (Meyer et al., 1979b).

On the other hand, political economic theories would argue that education reduces cultural and social distinctions between core and periphery, while paving the way for greater modernization—a process that serves the interests of urban and cultural elites and provides them with further incentives to “modernize.” Diffusion researchers note that an innovation is more expeditiously spread when diffusing agents are homophilous with adopters (Rogers, 1995), suggesting that national populations that share a “cognitive template” (Strang and Meyer, 1993) with developed nations via formal education are much more likely to embrace the Internet.

Education’s role in modern economic progress should therefore be pervasive because its effects at the macrosocial level are no less important than those found at the microsocal level. Of course, this should be particularly true for types of post-industrial change that hinge on information (e.g., the Internet), which is generally the conclusion of Internet diffusion researchers (Bazar et al., 1998; Danowitz et al., 1995; Press, 1995; Press, 1996; Press et al., 1998; Ruth and Schware, 1996; The Mosaic Group, 1998; Yahya, 1993).

3.4. Sectoral development

While many of the dimensions discussed above constitute the supply side of Internet development, the existence of a strong services sector, which includes information science, information technology, and other knowledge-intensive fields, should exert a substantial, direct demand for Internet development. A complex service sector suggests an increasingly socially and occupationally specialized society that encourages the need for advanced communications and transportation or, as noted by Bell (1973, p. 30): “The post-industrial society . . . is a ‘game between persons,’ but a game between persons requires increasing amounts of coordination. . . .” The tertiary sector thus breeds networks knit together in complex interdependencies, an environment that places a strong premium on innovation in communications technology.

As the post-industrial thesis posits, services quickly outgrow their role as the “junior partner” in development, a role that may have been unfairly assigned in the first place. In fact, since the service sector’s share of employment and gross domestic product tend to increase faster than the

industrial sector's share regardless of the level of development (Sundrum, 1990, pp. 28–32), it is entirely possible that the tertiary and quaternary sectors are not epiphenomenal of industrialization at all. This possibility is reinforced by noting also that the tertiary predates the industrial sector in most historical cases (Riddle, 1986, p. 35).

On the other hand, while we predict that strong service sectors will encourage Internet diffusion, we must acknowledge a more complicated reality in the developing world. For instance, the view of service economies as accretions of dead-end and/or informal activities that add little to a nation's productive capacity (e.g., Evans and Timberlake, 1980) complicates investigations of nascent "post-industrialism" in LDCs. Obviously "hypertrophic" or "bloated" (i.e., impoverished and informal) tertiary sectors may not encourage Internet diffusion, but unfortunately there is no satisfactory way to "tease out" the budding post-industrial from the hypertrophic using existing cross-national data. Considering this, we expect that service dominance will exert an effect on Internet development, but only in combination with the other dimensions discussed above.

3.5. Theoretical expectations of interactions

Thus, it seems that a confluence of factors is necessary and no single factor will suffice to nourish Internet development. In other words, in addition to their simple additive effects, the dimensions of modernization described above are also likely to interact with one another in shaping the development and diffusion of the Internet. Specifically, given that post-industrialism is a "game between persons," we might expect interactions between a society's educational foundation and its other dimensions of modernization—as these factors suggest a more complicated and sophisticated economy and society that is based largely on the transfers of information from person to person, organization to organization. Thus, interacting education with political context, service sector percentage and industrial development should provide a series of measures for the concept of post-industrialism.

For instance, one would expect to see an interaction between education and the proportion of the labor force employed in the service sector. The effect of services on Internet diffusion, in other words, is conditioned by the degree of literacy and computer skills in the population. The proportion of the labor force involved in the service sector alone will not be enough to encourage adoption of the Internet, but when highly developed tertiary sectors are matched by highly skilled labor forces then we would expect to see very rapid diffusion of the Internet. As we mentioned earlier, no comprehensive data exist that articulates the distinctions between domestic services and advanced information services sectors. It seems likely, however, that this measure taps the advanced services sector. If so, then we have obtained a direct indicator of the post-industrial.

In addition, the educational capacity of a nation may interact with the degree of industrialization to produce higher levels of Internet capacity. In other words, while industrialization provides the affluence or income level that makes the development of the Internet possible, this development is *supercharged* if the population has the cognitive wherewithal to embrace advanced, diverse, and personalized telecommunications.

Finally, a more open political regime allows its people to maximize their educational capital in pursuing communications for business and pleasure. Open political systems that also enjoy a well-educated labor force would be particularly enticing to new high-tech investment ventures, whether through domestic or foreign capital.

4. Methods and design

The present study examines Internet development in both developed and developing countries using approximately 74 observations in the base models.³ With the exceptions of the dependent variable as well as labor force in

³ The following lists the countries in all the models for Tables 2 and 3. Capitalized countries are found in every model. The superscript denotes those models that contain the specific cases. Angola^(Models 5-9), Albania^(Models 5-9), ARGENTINA, AUSTRALIA, AUSTRIA, Belgium^(Models 5-12,13), Burkina-Faso^(Models 5-8,12-13), Bulgaria^(Models 5-8,11-13), BRAZIL, CANADA, Switzerland^(Models 5-9,11-13), CHILE, China^(Models 5-9,11-13), CAMEROON, COLOMBIA, COSTA RICA, Cuba^(Models 5-7,9,12-13), DENMARK, DOMINICAN, REPUBLIC, ALGERIA, ECUADOR, SPAIN, ETHIOPIA, FINLAND, FRANCE, GHANA, GUINEA, GREECE, Hungary^(Models 5-9,11-13), INDONESIA, INDIA, IRELAND, ISRAEL, ITALY, JAMAICA, JAPAN, KENYA, KUWAIT, MOROCCO, MEXICO, MALI, Mongolia^(Models 5-9,12-13), Mozambique^(Models 5-9-12-13), MAURITIUS, MALAYSIA, Niger^(Models 5-10,12), Nigeria^(Models 5-10,12), Nicaragua^(Models 5-10,12), NORWAY, NEPAL, New Zealand^(Models 5-9,11-13), Oman^(Models 5-9,12-13), PAKISTAN, PANAMA, PERU, PHILIPPINES, Poland^(Models 5-9,11-13), Portugal^(5-8,11-13), Paraguay^(Models 5-10-12-13), Romania^(Models 5-9,11-13), Saudi Arabia^(Models 5-10,12-13), Singapore^(Models 5-10,12-13), SWEDEN, SYRIA, THAILAND, TRINIDAD, TOBAGO, TUNISIA, TURKEY, TANZANIA, UNITED KINGDOM, URUGUAY, UNITED STATES, VENEZUELA, ZAMBIA. The following lists the countries in all the models for Table 4. Angola^(Models 14-17,19-21), Albania^(Models 14-17,19-21), ARGENTINA, AUSTRALIA, AUSTRIA, Belgium^(Models A1-5-7-8), Burkina-Faso^(Models 14-17,19,21), BRAZIL, Switzerland^(Models 14-17,19-21), China^(Models 14-17,19-21), CHILE, CAMEROON, COLOMBIA, COSTA RICA, DENMARK, ALGERIA, ECUADOR, SPAIN, ETHIOPIA, FINLAND, FRANCE, GHANA, GUINEA, GREECE, Hungary^(Models 14-17,19-21), INDONESIA, INDIA, IRELAND, ISRAEL, ITALY, JAMAICA, JAPAN, KENYA, KUWAIT, MOROCCO, MEXICO, MALI, Mongolia^(Models 14-17,19,21), Mozambique^(Models 14-17,19-21), MAURITIUS, MALAYSIA, Niger^(Models 14-6,8), Nigeria^(Models 14-19,21), Nicaragua^(Models 14-19,21), NORWAY, New Zealand^(Models 14-17,19-21), Oman^(Models 14-17,19-21), PAKISTAN, PANAMA, PERU, PHILIPPINES, Poland^(Models 14-17,19-21), Portugal^(Models 14-19,21), Romania^(Models 14-17,19-21), Saudi Arabia^(Models 14-19,21), Singapore^(Models 14-19,21), SWEDEN, SYRIA^(Models 14-19,21), THAILAND, TRINIDAD, TOBAGO, TUNISIA, TURKEY, TANZANIA, UNITED KINGDOM, URUGUAY, UNITED STATES, VENEZUELA, ZAMBIA.

services, the political variable, sectoral inequality, ethnic homogeneity, and British colonialism (sources noted below), the remainder of the variables considered below come from the World Bank World Development Indicators CD (1997). The raw data for the dependent variable is available from the World Bank CD (1997 and 1998) and on-line through an organization named Network Wizards (2001). This organization has been conducting an *Internet Domain Survey* once or twice a year since 1981, although an adequate number of cases becomes available only after 1995.

We chose OLS regression because of its wide use in cross-national studies. Although we considered using a factor analysis to create a latent construction called “post-industrialism,” we ultimately decided that OLS analysis of discrete variables was preferable given our interest in opening the “black box” of “post-industrialism” (i.e., determining how different aspects of post-industrialism differentially impact Internet development, how and if each is mediated by teledensity, and how each variable interacts with education). Preliminary results indicated that most of the variables were moderately to highly skewed due to the nature of the population under study. Consequently, performing a regression analysis with these variables might present some difficulties in using OLS to analyze the data. For the sake of consistency, all variables used in the analysis have thus been logged.

Our study proceeds in three steps. First, the dependent variable is regressed on our theoretical model which incorporates the level of development, political openness, secondary school enrollment ratios, the percentage in the labor force working in services, and multiplicative terms between schooling and these variables (see Set 1). Second, we take this base model (although, to reduce multicollinearity, we retain only the interaction between schooling and tertiary labor force) and subject it to a variety of control variables that include the stock of foreign investments, ethnic homogeneity, sectoral inequality, population density, economic openness, and British colonial heritage (see Set 2). Finally, in our last analysis, we consider the influence of teledensity as a “proximate determinant” that may mediate some of the structural effects found in steps 1 and 2 (see Set 3) (commas denote simultaneous entry of variables, whereas ‘/’ means discrete entry).

$$\text{Set 1 : } Y = f\{EC, PO, ED, TERT, ED * TERT / ED * PO / ED * EC\}$$

$$\text{Set 2 : } Y = f\{\text{EQUATION1, FI / EH / GIN / PDEN / EO / BRIT}\}$$

$$\text{Set 3 : } Y = f\{TD, EC, PO, ED, TERT, ED * TERT, \\ \text{FI / EH / GIN / PDEN / EO / BRIT}\}$$

where Y, Log of Averaged Internet Hosts per 10,000 people, 1995–99; EC, Log of Energy Consumption per Capita, 1990; DE, Log of Political Openness, 1994; TD, Log of Telephone Mainlines per 1000 people, 1995; ED, Log

of Secondary Educational Enrollment Ratio, 1985; TERT, Log of Percent Labor Force in Tertiary Sector (ca. 1990); FI, Log of Stock of Foreign Direct Investment, 1995; EH, Log of Ethnic Homogeneity (ca. 1980); PDEN, Log of Population Density, 1995; GIN, Log of GINT Coefficient of Sectoral Inequality, 1970; EO, Log of Exports + Imports as Percentage of GDP, 1995; BRIT, British Colonial Heritage, dummy variable.

4.1. *Dependent variable*

The dependent variable, Internet Capacity, is operationalized as a country's number of Internet hosts per 10,000 population. Specifically, these Internet hosts are categorized according to their top level *domain name suffixes* such as .uk or .ar for the United Kingdom or Argentina. These suffixes are comparable to the commonly found .org, or .edu in the United States (note: “.com’s” are assumed to be United States domains). However, the top-level domain name measure does not include all hosts within a nation. For instance, a UK Internet address might also use the suffix “.com” rather than “.uk”; consequently, those with non-corresponding top-level domain names are not included in the data. Nonetheless, a significant proportion of Internet addresses in the UK use the appropriate suffix; an Internet host with a .uk suffix is likely to be located in the United Kingdom and likewise for all the other international suffixes. Thus, this is generally an approximate measure for Internet capacity within a nation and is the best indicator currently available. As a check, we obtained more refined Internet host data from a company that specializes in analyzing and locating Internet traffic, congestion, and capacity the world round.⁴ Specifically, their Internet host data correct for the varying proportions of “.coms,” “.orgs,” and so forth in Network Wizards' data. In this way we were able to ensure that our predicted models would truly approximate the reality of Internet penetration (see the appendix for the discussion of the results using these data).

Hypothetically, at least, sufficient data exist for a longitudinal analysis (1995–1999), but the autocorrelation between the dependent and lagged dependent variables makes such an analysis questionable. For this reason, we compile an *average* Internet host count including all the data from these five years, yielding an average number of Internet hosts per 10,000 for this five-year-period. This also mitigates concern surrounding measurement error for any one year. While this disallows longitudinal analysis, it does result in better coverage and a more stable indicator (see the appendix for analyses using a single year as the dependent variable).

⁴ We obtained the new Internet Host measure from Matrix Information Directory Services, a company that specializes in refining the raw Internet data from Network Wizards and localizing it within specific geographic contexts. For more information see <http://www.matrix.net>.

4.2. *Independent variables*

We adopt our general measure of development, the log of energy consumption per capita, from the World Bank (1997), following a long precedent in cross-national studies. This is defined as energy consumption per capita measured in kilograms of oil equivalent for the year 1990, a recent year that maximize sample sizes (see the appendix for additional controls for the presence of developed countries in the sample). Moreover, we use a measure for telecommunications infrastructural development in our final analysis, again adopted from the World Bank (1997). This teledensity variable is the number of telephone mainlines per 1000 people for 1995.

We measure political openness using a subjectively ranked political variable representing the “general openness of political institutions” (Jagers and Gurr, 1996), as reported in the *Polity III* data set (which covers the years between 1880 and 1994). The variable, scored from 1 to 10 with 10 indicating the most “open,” can be considered a measure of democratization measuring elective government and constitutional constraints on governmental power.

We operationalize the education variable as secondary school enrollments in 1985 as a percentage of the population in that age category. Given the likelihood that a considerable lag time exists between the acquisition of the knowledge and skills and its impact on economic matters (such as adoption of the Internet), we have lagged this variable back into the mid-1980s.

Percentage of the labor force in the tertiary sector was obtained from the International Labour Office’s *Yearbook of Labour Statistics*, reported for various years but generally around the year 1990 (International Labour Office, various years). The ILO does provide subsectoral breakdowns for some countries that partition the tertiary into consumer services and producer services. Nonetheless, while the use of such breakdowns might help to better pinpoint the “post-industrial” syndrome in developing countries, both types of service in fact contain a mixture of traditional services and what are now called “quaternary sector” activities. For this reason, as well as to preserve sample sizes, we use the aggregated tertiary figures.

4.3. *Control variables*

Foreign direct investment is a series of external inputs that may determine an economy’s output of goods and services, including telecommunications technologies like the Internet. Furthermore, the level of foreign monetary inputs may reflect integration into the global economy, for better or worse, and hence the potential to join the telecommunications revolution. Foreign investment probably has a larger effect for those nations that are still developing. On another level, higher amounts of investment suggest

greater political/social openness to external change, again a prerequisite for cultural and technological diffusion and development. We measure this important political-economic variable by controlling the net inward stock of foreign direct investments as a percentage of GDP in 1995 (World Investment Report, 1998).

A society's ethnic, cultural, or linguistic composition may also hold consequences for its communications development. Ethnic heterogeneity can lead to internal conflicts, retard "cultural diffusion" and economic development, and vitiate interregional or intergroup cooperation (Easterly and Levine, 1997). In ethnically homogeneous societies, the processes of communication should be more fluid and less prone to breakdown and stalling, as Roger's (1983) homophily principle of diffusion suggests. In addition, multiple groups vying for political dominance may make collective decision-making difficult, including goals such as the provision of telecommunications infrastructure. We adopt ethnic homogeneity, the percentage of the population belonging to the majority ethnic/linguistic group, from Vanhanen (1991).

According to ecological theory, population size and density reflect social adaptation to a given environment (Boserup, 1981; Hawley, 1968). In other words, a population responds to environmental constraints either by developing and adapting technology to maximize its resources or by reducing its size or concentration. Since population and available resources are constantly seeking balance, a dense population suggests a historical process of economic competition and technological innovation. These societies experience an increasing social division of labor which is a manifestation of the competition for survival. The emergence of a society into the post-industrial revolution would indicate population size because a denser population forces occupational and hence technical specialization—the very type of specialization and modernization that allow for such telecommunications developments (Wheeler and O'Kelly, 1999). We include population density for 1995 as a very basic proxy for this ecological thinking (World Bank, 1997).

Generally, the level of inequality in a nation should influence the degree of Internet development. Telecommunications are generally concentrated at the top economic levels, while those at the bottom or even in the middle may be somewhat removed from the local and international economies that utilize new communication technologies. Thus, telecommunications development is likely to be unevenly distributed socially and spatially. Those nations with higher levels of internal inequality should experience lower levels of Internet capacity compared to nations with less inequality. As a proxy for generalized economic disarticulation, we include the GINI coefficient of sectoral inequality for 1970, an indicator that gauges the disparity between labor productivity in agriculture and non-agriculture (Taylor and Hudson, 1972). This measure suggests the degree to which a nation's rural population

is “ghettoized” in subsistence agriculture, thereby promoting a sharp dualism in economic structure.

We have also included a measure of the sum of export and import values as a percent of GDP for 1995 (World Bank, 1997). We incorporate this measure in the belief that societies open to the world system of global trade are more likely to embrace its trappings, in this case the Internet. In short, the greater a country’s ‘external’ economy, the greater its connection to the world economy and its electronic coordination/control networks. Just as importantly, greater and more intensive contact with the “globalization” process may lead to higher levels of societal acceptance of “modern” institutions and technologies, a process which in turn may lead to more extensive dependence on core nations, corporations, and organizations to develop advanced telecommunications infrastructure.

Finally, as noted above, the Internet is Anglophone in that a large plurality of its users speak English and share some types of English heritage (e.g. US dominance of the Internet—see Hedley, 1998; Hargittai, 1999). Given this, we extend the logic of diffusion theory by expecting linguistic/cultural homophily to lend considerable energy to Internet diffusion. Consequently, those nations which are linguistically or culturally homophilous with Anglophone nations will probably have a greater likelihood of Internet presence and capacity than non-Anglophone nations, all things being equal. British colonial heritage, which codes all former British colonies (and of course Great Britain) as 1, are adopted from Bank (1978).

Outlier diagnostics for the base models in the first table suggest that three cases are influential: Algeria, Saudi Arabia, and Syria (Mongolia and Nepal are influential in the base models that include the interaction of education and energy consumption and the interaction of education and political openness, respectively). However, because omitting these cases from our analyses would not change our substantive conclusions, we use all available cases to estimate our models.

To correct for heteroskedastic disturbance terms, we apply White’s (1980) correction procedure for SEs in our reported models. Also, variance inflation factors and other collinearity diagnostics point to some multicollinearity generated by incorporating multiplicative effects, which is to be expected, but our reported coefficients and significance tests are nonetheless quite stable. We conclude that our analyses conform to OLS assumptions.

4.4. Analysis

Table 1 presents the zero-order correlations and corresponding sample sizes for the variables in the analyses. All of our theoretically relevant variables are positively and significantly related to the number of Internet hosts, with teledensity sharing the strongest correlation. Among the controls, the logs of foreign investment, ethnic homogeneity, population density, and

Table 1
Zero-order correlations between modeled variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Log of Internet hosts		.93	.96	.106	.96	.97	.87	.85	.86	.108	.97	.118	.80	.90	.119
2. Log of political openness	.65*		.85	.85	.85	.86	.80	.85	.79	.86	.87	.92	.71	.72	.93
3. Log of energy consumption	.79*	.47*		.86	.86	.85	.78	.79	.86	.90	.86	.95	.71	.76	.96
4. Log of telephone lines/k	.87*	.66*	.93*		.88	.88	.80	.78	.79	.96	.89	.105	.74	.82	.106
5. Log of secondary education	.69*	.49*	.85*	.85*		.87	.87	.85	.86	.92	.87	.95	.73	.77	.96
6. Service sector	.71*	.58*	.84*	.84*	.82*		.87	.80	.78	.92	.92	.96	.76	.76	.97
7. School*service sector	.77*	.62*	.90*	.90*	.95*	.95*		.80	.78	.85	.83	.86	.69	.71	.87
8. School*democracy	.68*	.99*	.47*	.67*	.47*	.59*	.60*		.79	.82	.80	.84	.67	.69	.85
9. School*energy	.79*	.49*	.98*	.98*	.93*	.85*	.95*	.49*		.84	.78	.85	.65	.71	.86
10. Log of foreign investment	.32*	.34*	.17	.20	.13	.28*	.26*	.36*	.16		.91	.107	.77	.90	.108
11. Log of ethnic homogeneity	.44*	.26*	.61*	.60*	.63*	.59*	.64*	.28*	.63*	.17*		.96	.80	.77	.97
12. Log of population density	.19*	.15	.11	.25*	.24*	.18	.20	.15	.13	.00	.14		.79	.89	.118
13. Log of inequality	-.70*	-.50*	-.60*	-.62*	-.60*	-.53*	-.61*	-.56*	-.66*	-.24*	-.39*	-.27*		.67	.80
14. Log of exports + imports/GDP	-.47*	-.39*	-.50*	-.48*	-.49*	-.46*	-.48*	-.41*	-.52*	.04	-.36*	-.07	.54*		.90
15. British colonial status	-.08	.01	-.11	-.17	-.11	.01	-.07	.02	-.15	.23*	-.19	.24*	.10	.28*	
Mean	.34	.77	6.60	4.17	3.79	3.64	14.18	3.58	26.40	-2.26	4.15	3.99	3.03	-19.99	0.17
SD	3.53	1.42	1.71	1.82	.80	.66	4.73	5.77	1.52	1.52	.45	1.38	0.87	2.13	0.38

* $p \leq .05$ (Sample sizes for each correlation appear above the diagonal in the matrix).

sectoral inequality share the expected relationships with the log of Internet Capacity, although only the correlation between sectoral inequality and the dependent variable has a magnitude similar to the theoretically relevant variables such as energy consumption or political openness. Of course, the moderate to high correlations between some of the theoretical variables suggest the need for multivariate analysis.

Table 2 reports the unstandardized coefficients for our base models. Model 1 demonstrates the strong influence of development (i.e., the log of energy consumption per capita) on Internet Capacity. This variable alone explains 62% of the variance in Internet development around the globe. On the other hand, development subsumes variance that in fact should be attributed to other dimensions. In Model 2 we see that the log of political openness exerts a unique influence on Internet Capacity net of development level, added another 11% to explained variance (adjusted $R^2 = .73$ versus $.62$ for Model 1). Models 3 and 4 suggest that our other theoretical variables, the logs of secondary educational enrollment ratios and the percentage of the labor force in the tertiary, are not significantly related to Internet development. On the other hand, these main effects are conditioned by each other, as demonstrated by Model 5. To interpret, while the effects of the logs of energy consumption and political openness diminish to some degree, the main effect of the log of secondary schooling is a -3.60 when both main effects are held at *zero* (given that this multiplicative term uses ratio-level variables) and the main effect of the log of tertiary employment is a -5.21 , again when both variables are held at zero (which explains the sharp negative magnitudes of both coefficients). On the other hand, the multiplicative term is a positive 1.42 . This suggests that, as the log of tertiary labor force rises by one unit, the coefficient between schooling and Internet capacity becomes more positive by 1.42 units. Conversely, as the log of secondary schooling rises by one unit, the coefficient between the logs of Internet Capacity and tertiary labor force becomes more positive by the same 1.42 units. Put in more intuitive terms, the coefficient between schooling and Internet Capacity is positive after tertiary labor force rising above approximately 12% of the labor force, or from the alternative vantage point, the coefficient between tertiary labor force and Internet Capacity is positive after secondary schooling rises above 38% of the eligible population pool.

Models 6 and 7 can be interpreted in the same way. The significant, positive multiplicative term in Model 6 equals $.88$. This indicates that the negative coefficient between political openness and Internet Capacity becomes positive after secondary schooling rises above approximately 20% of the eligible population. Conversely, the negative effect of secondary schooling on Internet Capacity becomes positive after political openness surpasses a value of 2, a relatively low level of openness. Model 7 indicates the negative effect of energy consumption per capita on Internet development becomes positive

Table 2
The log of Internet hosts per 10,000 regressed on selected independent variables

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Intercept	−10.31 (.74)	−8.97 (.69)	−9.30 (1.03)	−8.85 (1.82)	5.80 (3.44)	−10.06 (1.78)	1.58 (2.43)
Log of energy consumption 1990	1.64*** (.11)	1.34*** (.12)	1.17*** (.25)	1.18*** (.35)	.98*** (.32)	1.01*** (.33)	−1.43* (.78)
Log of political openness 1994		.89*** (.17)	.93*** (.19)	.97*** (.26)	.86*** (−.26)	−2.63** (1.05)	.88*** (.25)
Log of secondary school enrollment 1985			.37 (.57)	0.44 (.53)	−3.60*** (.87)	.82* (.46)	−2.45** (.56)
Log of service sector ca. 1990				−.22 (.79)	−5.21*** (1.25)	−.06 (.78)	.23 (.75)
School*service sector					1.42*** (.35)		
School*openness						.88*** (.25)	
School*energy consumption							.62*** (.14)
<i>N</i>	96	85	79	75	75	75	75
<i>R</i> ²	.62	.74	.73	.72	.76	.75	.77
<i>R</i> ² adjusted	.62	.73	.72	.71	.74	.74	.75

SEs corrected using White's (1980) procedure. SEs in parentheses.

* $p \leq 0.10$ (one-tailed test).

** $p \leq 0.05$ (one-tailed test).

*** $p \leq 0.01$ (one-tailed test).

once secondary schooling tops the 10% mark, again a very low level of schooling. Alternatively, the negative influence of secondary schooling on Internet Capacity turns positive once energy consumption has surpassed about 41 kg of oil-equivalent energy usage per person, about the development level of Niger.

These interactions suggest that, starting from relatively low levels of each variable, schooling intertwines with other theoretically relevant effects to produce a greater development of the Internet than might be expected otherwise. In practical terms, the influence of development, democracy, and tertiary employment on Internet development are “supercharged” by formal, secondary education. As anticipated, human capital becomes increasingly important in a post-industrial world.

In Table 3 we repeat the analyses from Table 2 controlling for some selected alternative explanations. In these models we retain only the interaction term between secondary education and tertiary labor force to make the analyses manageable, although using either of the other two interactions would produce similar substantive conclusions (analyses not shown). Model 8 demonstrates that the higher the penetration of foreign capital, the greater the Internet development. In this case, a 10% increase in foreign stock over GDP results in a 2.3% increase in Internet hosts per 10,000. This confirms what Hudson (1997) and others have speculated: foreign investment apparently boosts a nation’s telecommunications infrastructure independently of development, political regime, education, and other social structural forces.

On the other hand, Model 9 does not confirm our expectations about ethnic/linguistic homogeneity. Although the parameter estimate is positive, it is far from statistically significant, inferring that whatever the supposed benefits are from cultural and ethnic unity, they must be mediated by other variables in the model. Model 10, however, points to a strong effect of sectoral inequality. All else equal, a 10% rise in sectoral inequality results in a 8.9% *decrease* in Internet development. We conclude that disarticulated economies, or those that have a strong dualism or schism between their modern sector and “traditional” subsistence sector, are much less able to embrace Internet development than are other nations.

Population density, like ethnic homogeneity, apparently exerts no strong influence on Internet development net of our base model (the coefficient is positive but quite weak). The same is true of economic openness (or trade dependency, as some would have it) and British colonial heritage. Neither gains purchase on Internet Capacity net of our base model.

In Table 4 we report our investigation of teledensity as a mediating factor in Internet development. Model 14 demonstrates that both the logs of energy consumption per capita and political openness are apparently mediated by telecommunications infrastructure. These findings, which are at least partially consistent with theoretical expectations, suggest that the main

Table 3
The log of Internet hosts per 10,000 regressed on selected independent variables and control variables

	Model					
	8	9	10	11	12	13
Intercept	5.83 (3.54)	3.85 (4.02)	4.81 (4.01)	5.85 (3.36)	1.72 (4.12)	5.79 (3.45)
Log of energy consumption 1990	.80*** (0.34)	.94*** (0.34)	.75** (0.37)	1.00*** (0.31)	1.05*** (0.20)	.97*** (0.32)
Log of political openness 1994	.71*** (0.25)	.85*** (0.27)	.72** (0.29)	.84*** (0.26)	.62*** (0.19)	.86*** (0.26)
Log secondary education 1985	−3.74*** (.92)	−3.35*** (.91)	−2.19* (1.25)	−3.82*** (.95)	−2.61*** (.88)	−3.58*** (.87)
Log of service sector ca. 1990	−5.57*** (1.27)	−4.95*** (1.23)	−3.43*** (1.22)	−5.35*** (1.26)	−4.48*** (1.17)	−5.21*** (1.27)
School*service sector	1.50*** (0.36)	1.35*** (.37)	0.95** (.43)	1.46*** (.35)	1.21*** (.27)	1.42*** (.36)
Log of foreign investment 1995	0.23* (0.10)					
Log of ethnic homogeneity		.31 (.60)				
Log of inequality 1970			−0.89*** (.32)			
Log of population density 1995				0.14 (.17)		
Log of exports + imports/GDP 1995					−.03 (.10)	
British colonial heritage						−0.02 (.51)
<i>N</i>	73	71	59	62	73	74
<i>R</i> ²	.78	.76	.79	.87	.76	.76
<i>R</i> ² adjusted	.76	.73	.76	.86	.74	.74

SEs corrected using White's (1980) procedure. SEs in parentheses.

* $p \leq 0.10$ (one-tailed test).

** $p \leq 0.05$ (one-tailed test).

*** $p \leq 0.01$ (one-tailed test).

Table 4
The log of Internet hosts per 10,000 regressed on selected independent variables and control variables, including both log of energy consumption and log of teledensity

	Model								
	14	15	16	17	18	19	20	21	
Intercept	−6.52 (1.06)	7.23 (2.96)	8.77 3.25	8.82 (3.86)	6.99 (3.51)	7.19 (4.46)	3.2 (3.5)	7.36 (4.37)	
Log of teledensity 1995	1.35*** (.46)	1.74*** (.37)	1.70*** (.36)	1.93*** (.43)	1.70*** (.33)	1.7*** (.44)	1.38*** (.34)	1.81*** (.43)	
Log of energy consumption 1990	.19 (.41)	−.10 (.37)	−.07 (.40)	−.07 (.37)	−.08 (.35)	−.06 (.40)	.24 (.25)	−.12 (.39)	
Log of political openness 1994	.39 (.27)	.34 (.29)	.29 (.28)	.28 (.27)	.25 (.30)	.35 (.23)	.20 (.19)	.30 (.23)	
Secondary education 1985		−2.9*** (.72)	−3.14*** (.76)	−2.42*** (.86)	−1.62 (1.00)	−3.02** (1.33)	−2.44*** (.65)	−3.00*** (1.28)	
Log of service sector ca. 1990		−5.04*** (1.15)	−5.34*** (1.23)	−4.6*** (1.15)	−3.48*** (1.16)	−5.09*** (1.62)	−4.26*** (1.11)	−5.13*** (1.58)	
School*service sector		1.11*** (.27)	1.19*** (.29)	.97*** (.29)	.59* (.34)	1.4** (.43)	1.01*** (.23)	1.13*** (.42)	
Log of foreign investment 1995			.29** (.14)						
Log of ethnic homogeneity				−.97* (.57)					
Log of inequality 1970					−.94*** (.28)				
Log of population density 1995						.06 (.17)			
Log of exports + imports/GDP 1995							.02 (.08)		
British colonial heritage								.45 (.54)	
<i>N</i>	68	68	68	66	55	67	58	68	
<i>R</i> ²	.78	.82	.83	.82	.83	.81	.90	.82	
<i>R</i> ² adjusted	.78	.80	.81	.80	.80	.79	.89	.80	

SEs corrected using White's (1980) procedure. SEs in parentheses.

* $p \leq 0.10$ (one-tailed test).

** $p \leq 0.05$ (one-tailed test).

*** $p \leq 0.01$ (one-tailed test).

avenue whereby development and political regime create the potential for Internet capacity is through their creation of public infrastructure, in this case telephone mainlines. While we had expected development and democratization to have unique influences beyond teledensity (i.e., they should be weakened by entering teledensity but not washed out as they are here), the fact that they do not still comport well enough with modernization and political economy. Development generates the demand and fiscal capacity brings about the provision of telephone mainlines, while political openness removes many political and legal barriers to such provision. Current speculations on Internet development are therefore correct in emphasizing teledensity as approximate determinant of the Internet's potential.

The only other finding of note is the *negative* influence of ethnic/linguistic homogeneity once teledensity has been controlled in the equation. Although some account could be concocted that might place this finding into a context that makes sense (e.g., one could argue that nations with more ethnic diversity are more likely to adopt the Internet because they communicate in diverse languages and therefore are more exposed to the international features of the Internet, while nations that have a common heritage and language have to reach the "bootstrapping" stage to have the Internet take off), we should note that this coefficient is only marginally significant

Moreover, our diagnostics suggest that outliers may play a larger role in this finding than elsewhere in our models. For this reason we believe that more research needs to be done before we conclude that homogeneous populations actually *retard* Internet development. We think it is far more likely that a positive effect of ethnic homogeneity (seen in the bivariate case in Table 1) is probably mediated by other variables in the model, and that a few outliers unique to this equation produce the counterintuitive sign of this coefficient. We do note that the log of ethnic homogeneity is significantly correlated with most of the other variable in our analyses, which lends some weight to our speculation in this regard.

5. Discussion

The present investigation reveals that Internet capacity is fundamentally predictable using current macrosocial theories of development. Aside from the influences of development level and political freedom on Internet development, which are very intuitive, our most important observation is that educational attainment (measured here as secondary school enrollment ratios in 1985) conditions the influences of the other variables in our theoretical model. Foremost, mass education increases the influence of tertiary labor force on Internet capacity (and vice versa). Additionally, the other two interactions tested here, between education and development level and

education and political openness, are also significant, indicating that education is an important catalyst in the formation of post-industrial technologies and social structures. If the manipulation, consumption, and production of the *cyber* are quickly replacing the manufacture of “real” goods as the principal key function of post-industrializing societies, then education operates for post-industrialization very much as cheap labor did for industrialization. As developed nations can now attest, mass education is certainly the *sine quo non* of social change in the 21st century.

Secondarily, it is true that it does not require statistical analysis of cross-national data to identify those nations that will experience extreme difficulty in joining the information revolution. Countries like Ethiopia, Niger, Tanzania, or Laos will not be well-represented on the World Wide Web anytime soon. These countries, low on all the social structural characteristics we have identified as leading to Internet capacity, are simply too far behind to catch up in the near future. On the other hand, identifying the “up-and-comers” is a more difficult task. According to our analyses, there are several countries whose structural attributes should support more Internet development and usage (e.g., Jamaica, Botswana, much of Central America and South America, Indonesia, Korea, and several other “newly industrialized countries). Obviously, this does not undermine our findings, but merely suggests that a handful of exceptions to the rule exist. Only time will tell if these nations do in fact embrace the Internet, but they certainly do possess the minimum requirements we have identified to have a greater presence in the rapidly expanding global network of computers.

Of course, innovations could change these profiles. For instance, connectivity using satellite uplink may free the Internet from its prison of telephone mainlines, thereby allowing the spread of connectivity to even the remotest, least developed places on Earth (Kohn, 1997). Although we agree that such a shift in technology would increase the flexible and absolute size of the Internet, we seriously doubt it would change *relative* usage rates around the world. Literacy, the demands of the post-industrial economy, the size of markets for sophisticated goods, income distribution, and affluence thresholds will still prove constraining to Internet development and usage even in a world of expanded, aspatial connectivity. That is, problems on the ground will persist, and some countries will lag far behind even late into the century.

Another interesting finding is that the log of foreign direct investment as a percentage of GDP has a positive effect on Internet capacity net of other structural effects. Although we concede that the causal direction here is open to interpretation (i.e., perhaps MNCs are locating in areas that already have an Internet capacity), drawing the causal arrow from investment to Internet development is perfectly consistent with the modern multinational corporation’s need for global coordination and control. The negative effect of

economic disarticulation (sectoral inequality), however, suggests that serious gaps in the labor productivities of different sectors of an economy prohibit the emergence of suitable markets for information technology, even years in advance of such markets. Furthermore, this variable suggests that inequality is deleterious to post-industrial progress, an interesting finding considering the recent emphasis on the “digital divide.” Although this finding does not examine the reverse relationship, one could argue that if inequality proscribes further specialization in the information economy then a country’s ability to join in a rapidly changing global economy is partially circumscribed. It is just such circumstances that might vitiate the abilities of new technologies like satellite connectivity to allow developing countries to catch up.

Our results also suggest that the influence of development level and political openness on Internet diffusion are entirely mediated by teledensity. While this is not necessarily a great surprise, given that teledensity figures so prominently in theories of Internet diffusion, we think it unlikely that all the mechanisms driving the spread of the Internet related to development and political regime are wholly reducible to the provision of telephone mainlines. Certainly the affluence of a population, popular tastes for information and electronic entertainments, consumer markets, structures of taxation, and the ownership of intellectual property all condition Internet spread and usage, and these things are separable effects from telephony and its infrastructure. The present inquiry is limited to a cross-sectional design by the type of data addressed.

We have determined that macrosocial theories of development provide a suitable springboard for generating a *sociological* explanation for post-industrial dynamics. Nonetheless, this study focuses exclusively on the *determinants* of international Internet diffusion. While our findings suggest a blending of modernization, diffusion, and political economy best predicts the spread of the Internet, we have not addressed the Internet’s global *consequences*.

One interesting area of inquiry would be the effects on urban/technological enclaves and disarticulated economies (Jussawalla and Meheroo, 1980). The central question would be whether advanced telecommunications tend to “localize” economic activities outside of major urban/economic enclaves (Rudolph, 1996). In short, does the Internet encourage spatial and economic centripetalization or, as many have speculated, centrifugalization? The answer to this question is critical to many problems that currently plague the world’s megacities.

Another concern about the consequences of Internet diffusion is “cultural imperialism” (Hedley, 1998). Like telephony, the Internet and other technologies are bound to have certain consequences involving cultural/linguistic hegemony and therefore social control, cultural dominance, and the ability to wield symbolic power. Hedley emphasizes the

value-laden nature of this form of information diffusion, observing that US/Western hegemony in information technology poses the threat of an imposed cultural convergence on those who wish to “hook-up” to the global economy. Certainly the Internet is no respecter of borders and, as a consequence, is spreading a homogenizing culture around the globe, particularly among elites (Rudolph, 1996). While cultural and institutional diffusion is nothing new (Meyer et al., 1979a), telecommunications technology is unique in its speed and the high-quality of its transmission of ideas and information.

A related concern emanates from the world systems and dependency traditions. From these perspectives, diffusion of advanced telecommunications policies are potentially exploitive in the economic meaning of the term. Again, a well-developed infrastructure would encourage MNCs and other linkages with core economies, in turn further propelling telecommunications modernization. As the powerhouses of global capitalist regimes, these organizations would drive further inroads into the world system, a process which speeds modernization (i.e., industrialization and “post-industrialization) and potentially crowds out agrarian and other traditional economies. Moreover, this process of post-industrialization slowly builds dependence on developed nations’ technologies and markets. In other words, while increased development may follow from telecommunications-inspired dependence, developing economies require more inputs from and outputs to developed economies to keep the system afloat. Regardless, we will have to wait for future data to determine the vast panoply of “effects” telecommunications modernization is having on developing nations.

To sum up, an adequate understanding of the consequences of advanced information technology and telecommunications on global development is just beginning to coalesce. In the meantime, it is important to note that just as the Industrial Revolution was irreversible, so may be the post-industrial revolution. Developed regions like North America and Western Europe are soaring ahead of the rest of the world in development of the *cyber*. The corresponding social gaps and resulting consequences around the globe are destined to become important social issues, and just as the social sciences emerged as respectable disciplines due to the tumult of the Industrial Revolution, so the new information revolution provides many opportunities for new theories of post-industrialism.

Appendix A. Further analysis using reprocessed data

An anonymous reviewer felt that the relationships we found could be a process driven heavily by the inclusion of developed nations in the sample, suggesting that we either run our analysis with a dummy variable for

developed nations or a subset of our original dataset excluding the developed nations. Refining our study as such would allow us to test whether these relationships apply for the developing world as they do for the whole sample.

On an unrelated matter, a second reviewer expressed concern about the reliability of the dependent variable in covering all possible top-level domains for a nation. For example, each nation may have some proportion of its domains as “.coms”—a reality that is not included in the original national-level domain data. To cover both of the above concerns, we ran our three basic interaction models with a developed nations dummy variable and also excluded the developed nations with an adjusted dependent variable that corrects for the “neutral” suffixes. This dependent variable, Internet hosts per 10,000 for the year 2000, is calculated using reprocessed data we purchased from Matrix Information Directory Services. Essentially, these data meticulously match domains with their host nations, thereby resolving the misassignment problem inherent in the raw data.

The table in the Appendix begins with the same three interaction effects we examined in Table 2, with our more refined Internet host measure for the year 2000 (regressing a combined *average* of 2000 and 1995 on these basic interactions also shows the same patterns). As with the findings in Table 2, controlling for developed nations reveals no significant change for the interaction effects of secondary education and service sector, and secondary education and energy consumption—however, the interaction of schooling and political openness is no longer significant. Nonetheless, it should be noted that the *t* value of this interaction is very close to 1.65—a moderate “fit.” Interestingly, our dummy variable for developed nations is not significant, again illustrating the fact that these important relationships hold for the developing world.

Likewise, removing developed nations also reveals no change, again with the exception of schooling interacted with political openness. The lone failure of the interaction involving political openness when developed nations are excluded strongly suggests that this relationship is not as robust in the developing world—a result of sampling composition—and *not* an artifact of data error. With no significant change observed across dependent variables, subsamples and dummy variable controls for the other two interactions, we conclude that these patterns robustly hold for all nations in the models [19 nations comprise the developed dummy variable for this dataset (Models A4–A6), and subsequently are omitted from the third wave in the table (Models A7–A9). These nations are AUSTRALIA, AUSTRIA, BELGIUM, CANADA, DENMARK, FINLAND, FRANCE, IRELAND, ISRAEL, ITALY, JAPAN, NEW ZEALAND, NORWAY, PORTUGAL, SPAIN, SWEDEN, SWITZERLAND, UNITED STATES, UNITED KINGDOM].

The log of Internet hosts per 10,000 (year = 2000) regressed on selected interaction effects with subsamples controlling/omitting developed nations; SEs corrected using White's (1980) procedure (SEs in parentheses)

	Standard models			Controlling for developed nations			Developed nations omitted		
	Model A1	Model A2	Model A3	Model A4	Model A5	Model A6	Model A7	Model A8	Model A9
Intercept	5.15 (3.88)	0.89 (2.86)	-9.45*** (1.77)	3.31 (4.13)	-0.11 (3.04)	-8.93*** (1.70)	3.63 (4.41)	0.11 (3.29)	-8.95*** (1.73)
Log of political openness 1994	0.81*** (0.22)	0.84*** (0.22)	-1.74* (1.10)	0.75*** (0.23)	0.79*** (0.24)	-0.91 (1.07)	0.75*** (0.23)	0.79*** (0.24)	-0.93 (1.20)
Log of energy consumption 1990	0.97*** (0.33)	-1.13 (0.86)	1.04*** (0.34)	0.93*** (0.35)	-0.91 (0.81)	0.98*** (0.36)	0.90*** (0.36)	-0.99 (0.86)	0.95*** (0.37)
Log of service sector ca. 1990	-4.37*** (1.31)	0.62 (0.71)	0.35 (0.73)	-3.63*** (1.51)	0.63 (0.70)	0.40 (0.73)	-3.74*** (1.63)	0.64 (0.71)	0.42 (0.73)
Log secondary education 1985	-3.49*** (1.00)	-2.34*** (0.73)	0.55 (0.55)	-2.94*** (1.15)	-2.03*** (0.84)	0.45 (0.51)	-3.00*** (1.23)	-2.07*** (0.92)	0.49 (0.52)
<i>School*Service Sector</i>	1.31*** (0.37)			1.12*** (0.39)			1.15*** (0.43)		
<i>School*energy consumption</i>		0.54*** (0.16)			0.48*** (0.17)			0.49*** (0.18)	
<i>School*political openness</i>			0.64*** (0.26)			0.42 (0.26)			0.42 (0.30)
Developed nations dummy				0.53 (0.57)	0.42 (0.56)	0.75 (0.55)			
<i>N</i>	72	72	72	72	72	72	54	54	54
<i>R</i> ²	0.79	0.79	0.78	0.79	0.79	0.78	0.62	0.62	0.59
<i>R</i> ² adjusted	0.77	0.77	0.76	0.77	0.77	0.76	0.58	0.58	0.55

* $p \leq 0.10$.

*** $p \leq 0.01$.

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