The Distribution of Internet Use: A Cross-National Analysis[1]

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The wide adoption of the Internet is one of the most dramatic economic and technological developments in recent years. The International Telecommunications Union reports that in 2002 there were 591 million Internet users worldwide. In some countries, Internet adoption has had wide impact beyond pure consumptionCaffecting the internal operations of firms as well as dramatic innovations in marketing (Kenney 2003).

The dispersion of the Internet across the populations of the world is also dramatic. A common measure for the incidence of the Internet is the number of Ainternet hosts@ in a country. The measure is AY the number of computers directly connected to the worldwide network of interconnected computer systems@ (World Bank 1999, 245). The International Telecommunications Union reports that as of 1996, 96 percent of the Internet host computers were in high income countries that included only 16 percent of the world=s population. There were more Internet hosts in Finland than there were in all countries comprising Latin America and the Caribbean. New York City had more Internet hosts than all the countries of Africa.[2]

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[2]See www.itu.int/newsarchives/wtd/1999.

Table 1 contains some highlights of the variation of Internet connections across the world. The data in Table 1 show remarkable dispersion of Internet hosts. Angola has one hundred Internet host for

Table 1
Internet Hosts Per Ten Thousand Inhabitants

Country	Internet Hosts	Country	Internet Hosts
Angola	0.01	Australia	1,304
Botswana	7.57	Austria	451
China	0.68	Canada	963
Ecuador	2.63	Germany	314
Madagascar	0.15	Netherlands	1,937
Philippines	3.94	Singapore	479
Zimbabwe	3.04	United Kingdom	485

Source: International Telecommunications Union. Data are for 2002.
The US has 3,729 Internet Hosts per 10,000 inhabitants.

every 10,000 inhabitants. The Netherlands has more than nineteen hundred Internet hosts per 10,000 inhabitants. Indeed, the gap between the relatively poor countries in column one and the relatively rich countries in column two is striking and certainly seems to provide a simple explanationCthe dispersion of the Internet reflects the dispersion of the income across the countries of the world.

The data in Table 1 also reveal other dimension of dispersion. Consider the comparison of Angola and Botswana. Botswana has proportionately more than seven hundred times more Internet hosts than Angola. The Philippines have proportionately more than 26 times more Internet hosts than Madagascar. Thus, there is

considerable dispersion within the relatively poor countries and even within the relatively rich countries, as evidenced by comparisons of Australia and Austria. Understanding the reasons for such dispersion seems central to understanding the modern information based economy. This paper examines the question why Internet use is so prevalent in some nations and nearly nonexistent in other countries.

Background

A popular explanation for economic growth is the neoclassical growth model, most commonly associated with Solow, but also widely cited in an augmented form stressing human capital as well as traditional capital (Solow, 1956; Mankiw, Romer, and Weil, 1992). The model emphasizes the role of savings or investment, population growth, and
the natural diffusion of technology across counties as determinants of growth. A simple interpretation would be that if disparities exist in some application of technology, then they should be reasonably transitory. New technology should ultimately be widely distributed around the world. When new technology is developed, it is presumed to diffuse like an epidemic worldwide (Baumol, 1994). The framework implies that all countries worldwide should possess similar stocks of technology in equilibrium due to decreasing returns or imitation costs that are less than innovation costs. In short, neoclassical theory suggests there are plausible reasons to expect similar stocks of technology across countries. However, as a first approximation, the data in Table 1 clearly do not support the homogeneity of technology across countries. It is true that widespread Internet use is recent, so the market may not be in equilibrium. However, the data in no way fit closely with neoclassical growth model.

Other explanations for growth exist. These include Aendogenous growth models@ that permit continued relatively high growth for rich countries and that are attributable to increasing returns from various investments (Romer, 1986). Further explanations for growth focus on the role of institutions as engines of economic growth (Barro, 1992; Barro and Salia-I-I Martin, 1995; Knack and Keefer, 1995; North, 1981; Scully, 1988). Such models

constitute a loose theoretical perspective that could be labeled the neoinstitutional theory of growth. This alternative explanation permits important differences across countries in terms of investment and growth, including the stock of technology. It is compatible with the neoclassical theory or the endogenous growth theory, but it also asserts that a nation's technology is driven by the efforts put forth by its citizens. The efforts citizens exert are dependent upon incentives established in the nation. These in turn are established through laws and customs in a country. Laws and customs can encourage or discourage productive behavior and the gains-from-trade by lowering the costs of contracting and the costs of less formal transactions.

A related issue is that a number of human characteristics vary across countries and contribute to the speed and extent of the diffusion of technology. Abramovitz (1994, 97) classifies these factors under the rubric Asocial capabilities@ The level of human capital investment (e.g., years of education) of the citizenry is the most salient example.

Empirical evidence

In the attempt to understand the disparity of Internet use throughout the world, we examine the role of social capabilities and institutions using well-established statistical tests. Specifically, we estimate the following equation:

$$ln(Internet) = \beta_0 + \beta_1 Urban_i + \beta_2 Primary_i + \beta_3 Secondary_i + \beta_4 Higher_1 + \beta_5 Law + \Phi_p$$

where the dependent variable is the number of Internet hosts per 10,000 of the population. The variable labeled Urban is the proportion of a country=s population living in urban areas. It may be a social capability in the sense that many urban dwellers have more formal education than their rural counterparts and benefit more from the productive actions of the citizenry (Lucas, 1988). Thus, Urban should be a measure of social capability, but as a practical matter it is also a proxy measure of technological capability because urban areas should be associated with more extensive technological infrastructure

such as telecommunications facilities. Fixed installation costs are spread over more customers. In most circumstances, the telecommunication wires are used to access the Internet. Thus, this variable is used as a control variable, independent of human capital or institutional effects, to account for the distribution of the Internet among the countries of the world.

Primary, Secondary, and Higher represent educational attainment measures developed by Robert Barro and Jong-Wha Lee (1993). These variables represent the stock of human capital in a country that should be a large component of the Asocial capabilities@ of country. A greater stock of human capital in a country should mean enhanced capability to use a new and technologically enhanced product. The attainment measures seem particularly appropriate.

Empirical research using the stock of human capital involves numerous measurement problems. Input measures such as enrollment rates do not provide an accurate measure of the stock of human capital.

Output measures such as adult literacy do not provide a good picture of educational attainment because they describe only the most rudimentary levels of educational attainment. Moreover, various models of economic growth such as Lucas (1988) rely on human capital in the form of educational attainmentCthe number of school years completed. For these reasons, Barro and Lee (1993) estimate the number of school years completed for persons aged 25 and above using a Aperpetual inventory approach.@ While their measure does not adjust for important dimensions beyond educational attainment, e.g., quality, the measure is a reasonable representation of the existing stock of human capital in a country.

Primary represents the proportion of the population 25 and older for whom the highest educational attainment was a primary education, Secondary represents the proportion of the adult population whose highest attainment was a secondary education, and Higher represents the proportion of the adult population that attained a higher education. These social capability measures should be expected to increase the demand and supply for technology, including the relative incidence of Internet use.

Law represents the Arule of law.@ Knack and Keefer (1995) describe the rule of law measure as a variable that@... reflects the degree to which the citizens of a country are willing to accept the established institutions to make and implement laws and adjudicate disputes.@ Higher measures indicate sound political institutions, a strong court system, and provisions for orderly succession of power. Lower measures indicate a tradition of depending on physical force or illegal means to settle claims. These data are from the International Country Risk Guide provided by PRS Group, Inc.

Previous research by Knack and Keefer (1995) and Barro and Sala-I-Martin (1995) show that the rule of law is the most powerful institutional determinant of economic growth. At an intuitive level, this measure should contribute to lower contracting and transaction costs. Therefore, we should expect that the incidence of new technology, such as the Internet should be greater when the rule of law is stronger.

Full sample estimates

Table 2 contains ordinary least squares estimates of the equation above.[3] Both separate and combined regression estimates are reported. The data in Table 2 indicate a powerful relationship between Internet

[3]White=s heteroskedasticity corrected estimators are used. While (1980).

Table 2

Cross-National Determinants of Internet Hosts

Variable	Regression Coefficient/(t statistic)						
Intercept	-2.28	3.78	-6.62	-1.56	-4.16	-7.40	
		(-4.56)	(1.30)	9-7.25)	(-3.95)	(-7.66)	(-5.78)
Urban		0.08					0.02
		(9.60)					(2.30)
Primary Education		-0.38				0.28	
			(-0.47)				(0.93)
Secondary Education			2.92			0.62	
				(10.16)			(2.40)
Higher Education				2.04		0.74	
					(11.62)		(3.27)
Rule of Law					1.76	1.13	
						(15.17)	(9.16)
Ajd. R2		0.340	-0.007	0.443	0.564	0.561	0.813
S.E.R.		2.520	3.267	2.427	2.149	2.195	1.414
N		181	97	97	97	121	87

The dependent variable is the log of internet hosts in each country. t statistics are in parentheses. Internet hosts data are from the International Telecommun-ications Union. Urbanization data are from the World Bank, *World Development Indicators*, 2001. Educational attainment data are from Robert Barro=s web page. Rule of Law measures are from the International Country Risk Guide, PRS Group, Inc. The educational attainment data are in logs.

use and the independent variables.[4] All the variables except primary education have the predicted positive signs and are statistically significant well

[4]Urbanization, the educational attainment variables, and the rule of law are assumed to be exogenous. The recent advent of the Internet buttresses that

beyond traditional standards of significance. The explanatory power of the higher education attainment and rule of law variables is especially noteworthy with greater than 50 percent adjusted R^2 values.

The results for the combined estimate are shown in column six. The explanatory power of the full estimate is remarkable for a cross-sectional regression with an adjusted R^2 exceeding 80 percent. Urbanization and both secondary and higher education appear to be powerful determinants of Internet hosts. However, the most striking feature is the explanatory power of the rule of law variable. It strongly dominates the other variables. It is also noteworthy that while all the significant variables fall substantially in magnitude in the full estimates compared with the separate estimates, the rule law variable falls much less.

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assumption, as does the fact that these variables are predetermined all are for the year 1999, while the dependent variable, Internet hosts, is measured for 2002.

In addition to its statistical significance, the economic significance of the rule of law variable is noteworthy.[5] A one standard deviation increase in the rule of law measure would increase the percentage of Internet hosts by more than four hundred percent or an increase of 1,171 Internet hosts per 10,000 of the population at the sample mean.[6] Such hypothetical analysis is laden with caveats, but these data clearly indicate that the strongest determinant of Internet hosts in a country is institutionalCthe rule of law.

OECD versus non-OECD countries

The data in Table 2 document strong statistical support for the role of social capabilities and the rule of law. However, other omitted variables may be relevant and bias these estimates. Moreover, some logical extensions of the model exist.

One possible driving force behind the results delineated in Table 2 is that relatively rich countries may have more Internet connections because they can afford technological products and coincidentally are urbanized, relatively well educated, and enjoy the rule of law. Moreover, a number of researchers argue that there are fundamental differences between the economies of the industrialized worldCOECD countries, and the rest of the worldCnon-OECD countries (Baumol and Wolff, 1988; De Long, 1988). The argument holds that the economic processes are inherently different. Accordingly, we estimate our separately for the two groups of countries.

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[5]For a discussion of the role of economic significance, see McCloskey (1985) and McCloskey and Ziliak (1996).

[6]The one standard deviation is estimated for the sample of 87 observations used in Column 6. A standard deviation increase in urbanization would increase the number of Internet hosts by about 58 percent, while increases in secondary or higher educational attainment would increase by 38 percent and 56 percent, respectively.

A related difficulty is that usage rates can reflect the state of the technology**C**an interpretation that stresses the productive capabilities of Internet use, or they could also simply reflect the relative usage rates of a luxury good. Accordingly, it seems reasonable to estimate the equation with per capita GDP included as an independent variable.[7]

[7]The measures are for 1999 in 1995 dollars.

Separate estimates for OECD and non-OECD countries are shown in columns one and two of Table 3. The data point to some differences between the two group of nations. Urbanization plays a significant role for the generally more rural, non-OECD countries, but not for the OECD countries. In the former case, increased urbanization is associated with more Internet hosts. Primary education is irrelevant in both groups of countries. The proportion of Internet hosts is positively linked with secondary and higher education, but only for the OECD countries. The most relevant estimates are the ones involving the rule of law measure. The estimates are statistically significant and quite robust for both the OECD and non-OECD countries. Indeed, in both types of countries the rule of law strongly dominates the other variables.

Columns three and four in Table 3 contain estimates of Internet host equation with per capita GDP as an independent variable. Because educational attainment and the rule of law variables are thought to be determinants of GDP (Knack and Keefer, 1995; Barro and Sala-I-Martin, 1995), the estimates raise the possibility of including redundant variables. Accordingly, only variables that are demonstratively shown to not be redundant are reported.[8]

Secondary and higher education attainment are significant coefficients when GDP is included, but only for OECD countries. Education plays no direct role for non-OECD countries, although it may play a powerful indirect role by affecting GDP. The rule of law retains its significance in both types of countries. Compared to the estimates in column one and two, the magnitude of the coefficient increases in OECD countries but falls noticeably in non-OECD countries, presumably because much of the link between the rule of law and the proportion of internet hosts is due to the effects of the rule of law on GDP that in-turn increase Internet hosts.

[8]Redundant variable tests are used as the basis to exclude urbanization and secondary and higher educational attainment for non-OECD countries and primary educational attainment for both OECD and non-OECD countries.

The most striking results are for GDP itself. The estimate indicates that GDP is not significant for OECD countries. Educational attainment and the rule of law are the dominant variables. For the non-

Table 3
Cross-National Determinants of Internet Hosts
OECD and Non-OECD Countries

Variable	Regression Coefficient/(t statistic)			
	OECD	Non-OECD	OECD	Non-OECD
Intercept	-4.66 (-1.52)(5.07)	-7.66 (-2.69)	-2.68 (-11.19)	-11.22
Urban	0.00 (0.28)	0.04 (2.92)		
Primary Educ.	0.21 (0.44)	0.54 (1.30)		
Secondary Educ.	0.75 (2.30)	0.49 (1.55)	0.69 (2.99)	
Higher Educ.	1.13 (2.49)	0.49 (1.70)	1.03 (3.21)	
Rule of Law	0.68 (5.04)	0.93 (4.86)	9.75 (5.84)	0.38 (2.08)
GDP			-0.08 (-051)	1.52 (9.58)
Adj. R^2	0.748	0.635	0.756	0.640
S.E.R.	0.603	1.604	0.593	1.587
N	27	60	27	79

Source: See Table 2. The educational attainment and GDP variables are in logs.

OECD countries, GDP is important. It is statistically quite robust. Moreover, its coefficient is highCmore than 1.5, indicating that for the poorer countries of the world, Internet hosts are a bit of a luxury. However, the rule of law remains significant. It has a link directly with Internet hosts, independent of any indirect impact by increasing GDP. Thus, the data indicate that the rule of law is linked with greater proportions of Internet hosts for both OECD and no-OECD countries.

Refined measures of the Rule of Law

A second extension applies to refined measures of the rule of law. Recent empirical analysis shows that the rule of law is an important determinant of economic growth across countries. The data above show that the rule of law is also a powerful determinant of the distribution of Internet hosts across countries. However, legal systems vary in more refined dimensions. A logical extension of the empirical analysis above is to determine if additional characteristics of the law also contribute to the incidence of Internet hosts across countries The Economic Freedom project provides five additional measures of the law for a smaller sample of countries (Gwartney and Lawson, 2001). The measures are a ranking of a sample of countries on identifiable features of their respective legal systems. The rankings include impartiality of the judiciary, intellectual property protection, judicial independence, the absence of legal corruption, and the protection of private ownership. The measures represent the degree to which the courts operate within a trusted legal framework where businesses can challenge the legality of government actions, the legal protection of intellectual property from appropriation by nonowners of the property, the degree to which the legal system is not subject to interference from the government and parties to the disputes, the degree to which irregular payments to the judiciary or others are made, and the legal security of private ownership.

For more refined analysis, the fraction of Internet hosts in each country is regressed on the same variables as Table 2. In all cases, the more refined measures are also statistically significant. The

most robust estimate is the one that includes private ownership of assets. The results of the estimates are:

$$\begin{aligned} \textit{ln}(\text{Internet}) = {} & -12.52 + .02\ \text{Urban} + .96\ \text{Primary} + 1.00\ \text{Secondary} + \\ & (-3.85)\quad (2.77)\qquad (1.72)\qquad (2.30) \\ & 1.00\ \text{Higher} + .61\ \text{Law} + .43\ \text{Private Ownership} \\ & (3.11)\qquad (4.07)\qquad (2.73) \end{aligned}$$

Adj. R^2 =. 871 S.E.R= .882 N=49

Strictly speaking, these results are not exactly comparable to those above because the sample is not completely congruent. However, the results point to a strong positive relation between urbanization, all levels of educational attainment, and the rule of law. In addition, these estimates also point too a special role for private ownership in encouraging a milieu wherein investors have the confidence to acquire high technology assets and reap the benefits associated with those assets.

Conclusion

There is considerable dispersion of Internet hosts across countries. That fact is not consistent with the assumptions of diminishing returns to capital or relatively inexpensive imitation of new technologies compared to innovation. Moreover, the data indicate that the dispersion is systematic. The incidence of hosts increases with urbanization and educational levels, especially post-secondary education. The results are broadly consistent with several growth models and common sense. However, the relationship between the rule of law and the incidence of Internet hosts is especially robust and consistent with neoinstitutional explanations for growth.

The data do not provide a full explanation for the mechanism by which the rule of law leads to enhanced stocks of high technology goods. Presumably, the results are attributable to lower contracting or transactions costs or increased general investment incentives, but there is considerable further explaining to be done. The estimates using more refined categories for the legal variable suggest that simple protection of private ownership is important. However, it is sufficient for the present to note that the rule of law leads to increased stocks of technologically advanced capital and legal systems that protect private ownership enhance the use of technologically advanced products.

References

Abramovitz, Moses. 1994. Catch-up and convergence in the postwar growth boom and after, in William J. Baumol, Richard R. Nelson, and Edward N. Wolff, eds. *Convergence and Productivity*. New York: Oxford University Press: 97.

Barro, Robert. 1992. Economic growth in a cross-section of Countries, 106 *Quarterly Journal of Economics* 106: 407-43.

Barro, Robert and Sala-I-Martin, Xavier. 1995. *Economic Growth*. New York: McGraw-Hill.

Barro, Robert J. and Jong-Wha Lee. 1993. International comparisons of educational attainment. *Journal of Monetary Economics* 32: 363-394.

Baumol, William. 1994. Multivariate growth patterns: contagion and common forces as possible sources of convergence, in William J. Baumol, Richard Nelson, and Edward Wolff, eds. *Convergence and Productivity*. New York: Oxford University Press: 73.

Baumol, William J. and Wolff, Edward N. Wolff. 1988. Productivity, convergence and welfare: reply, 78 *American Economic Review* 1155-1163.

De Long, J. Bradford . 1988. Productivity, convergence and welfare: comment, 78 *American Economic Review* 1138-1154.

Gwartney, James and Lawson, Robert.2001. *Economic Freedom in the World*, 2001. Vancouver: Fraser Institute.

Kenney, Martin. The growth of the Internet in the United States, in Bruce Kogut, ed. *The Global Internet Economy*, Cambridge, MA: MIT Press.

Knack, Stephen and Keefer, Philip. 1995. Institutions and economic performance: cross-country tests using alternative institutional measures, 7 *Economics and Politics* 207-227.

Lucas, Robert E. Jr. 1988. The mechanics of economic development, 22 *Journal of Monetary Economi*cs 3-42.

Mankiw, N. Gregory, Romer, David and Weil, David N. 1992. A contribution to the empirics of economic growth. 107 *Quarterly Journal of Economics* 407-437(1992).

McCloskey, Donald N. 1985. *The Rhetoric of Economics*. Madison: University of Wisconsin Press.

McCloskey, Deidre N. and Ziliak, Stephen T. 1996. The standard error of regressions. 34 *Journal of Economic Literature* 97-114.

Douglass C. North. 1981. *Structure and Change in Economic History*. New York: W. W. Norton.

Romer, Paul M. 1986. Increasing returns and long-run growth, 94 *Journal of Political Economy* 1002-1037.

Scully, Gerald. 1988. The institutional framework and economic development, 96 *Journal of Political Economy* 652-662.

Solow, Robert A. 1956. A contribution to the theory of economic growth, 70 *Quarterly Journal of Economics.* 65-94.

White, Halbert. 1980. A Heteroscedasticity-Consistent Covariance Matrix and a Direct Test for Heteroscedasticity. 48 *Econometrica.* 817-38.

World Bank. 1999. *World Development Report,*1998/1999.