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# An examination of the relationship between digital divide and economic freedom: An international perspective

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## ABSTRACT

*Due to various economic, political and social reasons, the Internet usage remains relatively low in many countries around the world. The difference in access to new information technologies and the Internet among countries, is known as the "digital divide." This is a significant economic phenomenon that warrants the attention of analysts and policy makers. Furthermore, since information technologies and the Internet have proven to be key drivers for economic growth and global trade, many nations are in danger of being marginalized. This paper examines the relationship between economic freedom as indicated by the Economic Freedom Index (EFI), proposed by Beach and O'Driscoll (2003) and the digital divide. By analyzing data from sixty-two countries that include variables such as the cost of Internet access, number of personal computers and phones, personal income level, and innovation capability, it is shown that EFI is significantly related to the diffusion rate of the Internet. Therefore, countries need to examine and implement economic policies that are conducive to narrowing the digital gap.*

## INTRODUCTION

Information and communication technologies, when properly used, often act as key drivers of economic growth. During the late 90's, investments in IT resulted in significant economic growth – estimated to be around 10 to 20 percent of output growth, in the economies of countries such as Australia, Canada, Finland and the United States (Lawrence, 2002). Among the many IT innovations, the rapid diffusion of the Internet and accompanying e-commerce applications are frequently mentioned as the leading drivers of economic growth (Dedrick, et al., 2003; Forestier, et al., 2002; Kenny, 2003). These economic benefits are generally due to lower transaction costs, less price dispersion, broader and integrated competitive markets, and seamless communication capabilities. In fact, worldwide online transactions are proliferating. Globally, the online sales are expected to reach about 18 percent of business-to-business and retail transactions by 2006 (Forrester Research, 2001). In the U.S. alone, by 2006 nearly 26 percent of sales, mostly business-to-business, will be conducted online.

In spite of the fact that Internet use and e-commerce provide unique economic growth opportunities for nations, Internet penetration rates remain uneven and in fact low in many countries. For example in 2000, in Bangladesh and Nigeria, the Internet diffusion rates were below one percent (.04 and .09 percent, respectively) (International Telecommunications Union, 2002). On the other hand, this figure is nearly 60 percent in the United States and Sweden. This disparity in Internet usage and hence the inability to garner its benefits is commonly referred to as the "digital divide." Some economists and policy analysts contend that this "digital gap" and its consequences may especially marginalize developing countries, both economically and politically. In fact, some experts predict that at the current rate of digital divide, the degree of income and wealth inequality across nations will accelerate and may adversely affect the economic growth of many nations (Pohjola, 2001). Goldstein and O'Connor (2000) sum it up by stating that "... (this divide) will reinforce existing income and wealth inequalities within and between countries, and risk the future stability of the international community." Further, Ishaq (2001) notes that "... the Internet threatens to magnify the existing socioeconomic disparities, between those with access and those without, to levels unseen and untenable." In light of this state of affairs, many organizations including the United Nations (1999) are advocating urgent actions to bridge the global digital gap (United Nations, 2002). Progressive liberalization policies, economic reforms, and economic and educational assistance are some of the proposals that have been recommended to narrow the digital divide.

As noted above, there exists a large variation among the global Internet diffusion rates. Therefore, an understanding of the factors that contribute to this disparity should prove valuable to policy makers and political leaders in providing guidance in articulating strategies to narrow this gap. A limited number of research studies have examined the factors that are germane to global Internet diffusion (Beilock & Dimitrova, 2003; Dutta & Roy, 2003; Goodman & Press, 1994; Kiiski & Pohjola, 2002). A review of these studies shows that factors that contribute to the diffusion include the availability of a cost-effective telecommunication infrastructure, access to personal computers, education opportunities, income levels, and innovative capability of the country. Furthermore, additional hurdles must be overcome to become e-commerce ready (Oxley & Yeung, 2001). The rules of law (e.g., property rights, strong court system) governing the nation's trading system, the extent of governmental regulations and liberalization policies to keep markets open, and credible payment systems (e.g., credit cards, digital cash) have been mentioned as prerequisites for migration from traditional markets to e-commerce.

Given the relative paucity of research in global Internet diffusion and digital divide, this research empirically examines how a nation's economic freedom and factors such as the Internet access cost, telecommunications infrastructure (cell and fixed-line phone penetration rates, personal computer usage), income levels, and innovative capability of the nation, affect the Internet diffusion rate. In particular, this study focuses on the relationship between a nation's economic freedom and the Internet diffusion rate. Data from 62 countries for the period 2000-2001 are used for this analysis. A larger sample consisting of more countries could not be included in this analysis because of the lack of consistent data on many variables.

## METHODOLOGY

In order to specify a model that explains the diffusion rate of the Internet, several explanatory variables were considered. The diffusion rate for a country, the dependent variable, was measured by considering Internet usage per 100 inhabitants. This variable is named DIFF. The explanatory variables considered were:

- ITCOST: Average monthly cost of 20 hours of Internet access.
- PC: Number of personal computers per 100 inhabitants.
- TEL: Telephone lines per 100 inhabitants.
- CELL: Cell phone subscribers per 100 inhabitants
- INCOME: Real gross domestic product per capita (in U.S. purchasing power parity \$).
- INNOV: Innovative capability of the country. This variable is calculated as the product of the number of patents granted per million inhabitants in the year 2000 and gross tertiary enrollment rate in 1997. Note that the number of patents reflects the nation's innovation intensity and the enrollment rates denote the degree of investment in human capital. Thus, INNOV measure reflects a country's capability and capacity for innovation in technologies and products (McArthur & Sachs, 2002).
- EFI (Economic Freedom Index): Beach and O'Driscoll (2003) define this index as the "... absence of government coercion or constraint on the production, distribution, or consumption of goods and services beyond the extent necessary for citizens to protect and maintain liberty itself." This index aggregates several factors covering broad issues such as corruption, non-tariff barriers to trade, the fiscal burden of government, the rule of law and efficiency of the judiciary, regulatory hurdles for businesses, labor market restriction, and black market activities. Complete details regarding the development and description of this index can be found in Beach and O'Driscoll (2003). The values of EFI can vary from 1 to 5. A value of 1 indicates set of national policies that promote economic freedom and a value of 5 signifies policies that are least conducive to economic freedom.

The following maintained hypotheses are proposed explaining the rate of diffusion of the Internet by explanatory variables indicated above:

H<sub>1</sub>: There exists a negative relationship between the cost of Internet access (ITCOST) and the diffusion rate (DIFF).

H<sub>2</sub>: There exists a negative relationship between economic freedom index (EFI) and the diffusion rate (DIFF).

H<sub>3</sub>: There exists a positive relationship between domestic product per capita (INCOME) and the diffusion rate (DIFF).

H<sub>4</sub>: There exists a positive relationship between personal computer penetration rate (PC) and the diffusion rate (DIFF).

H<sub>5</sub>: There exists a positive relationship between cell phone penetration rate (CELL) and the diffusion rate (DIFF).

H<sub>6</sub>: There exists a positive relationship between fixed-line telephone penetration rate (TEL) and the diffusion rate (DIFF).

H<sub>7</sub>: There exists a positive relationship between innovation (INNOV) and the diffusion rate (DIFF).

It should be noted here that in hypothesis H<sub>2</sub>, EFI is an inverse measure of a nation's economic freedom – lower values of EFI signify greater economic freedom and higher values of EFI denote lower economic freedom. Therefore, one would expect a negative relationship between economic freedom and the Internet diffusion rate.

Data from 62 countries on these variables were compiled using several sources. Data for variables DIFF, ITCOST, INCOME, TEL, CELL, and PC were gathered from *The Global Information Technology Report 2001-2002*. The data to construct the variable, INNOV by combining the number of patents and education levels were obtained from *The Global Competitiveness Report 2001 - 2002*. As mentioned above, the data on Economic freedom index (EFI) were obtained for various countries included in this research, from Beach and O'Driscoll (2003). To assure consistency, these data were checked against the databases from the home pages of *The International Telecommunication Union* (2002) and *World Development Indicators* (World Bank, 2002).

## ANALYSIS AND RESULTS

Table 1 lists the sixty-two countries used in this study. The table also reports their Internet diffusion rates. At the lower end with diffusion rates below one percent include countries such as Bangladesh, Nigeria, Vietnam, Zimbabwe, Paraguay, Ukraine, India, Guatemala, Honduras, Sri Lanka, and Indonesia. At the other extreme, are Sweden, the United States, and Iceland with diffusion rates between fifty and sixty percent. Table 2 shows the correlation matrix for variables considered. Note that as expected, the number of telephones, cell phones, personal computers, income and innovation index are all significantly positively correlated with DIFF at the 0.01 level. Furthermore, Economic Freedom Index (EFI) shows a significant negative association with DIFF. This is expected as lower values of EFI signify a higher level of economic freedom while higher values of EFI represent a lower level of economic freedom. Thus, increased economic freedom and increased diffusion rate move together. It is note worthy that ITCOST does not correlate significantly with any variable. As a starting point, for empirical analysis, the following regression model is postulated:

$$\begin{aligned} \text{DIFF}_i = & \beta_0 + \beta_1 \text{ITCOST}_i + \beta_2 \text{EFI}_i + \beta_3 \text{INCOME}_i + \beta_4 \text{PC}_i \\ & + \beta_5 \text{CELL}_i + \beta_6 \text{TEL}_i + \beta_7 \text{INNOV}_i + \mu_i \end{aligned} \tag{1}$$

In this regression model,  $\mu_i$  are the stochastic error terms associated with model (1) ( $i = 2, \dots, 62$ ), which are assumed to be homoscedastic and normally distributed. Also, all the variables, in model (1), are expressed in natural logarithms and therefore, their regression coefficients represent elasticities. Note that hypotheses  $H_1 - H_7$  correspond respectively to stating that  $\beta_1 < 0$ ,  $\beta_2 < 0$  and  $\beta_3$  through  $\beta_7 > 0$ .

**Table 1. Internet Diffusion Rates**

Diffusion Rate	n	%	COUNTRIES
<1%	11	17.8%	Bangladesh, Nigeria, Vietnam, Zimbabwe, Paraguay, Ukraine, India, Guatemala, Honduras, Sri Lanka, Indonesia
1% - 3%	10	16.1%	Panama, China, Jordan, Thailand, Columbia, Russian Federation, Jamaica, Philippines, Mexico, Bulgaria
3% - 5%	4	6.5%	Turkey, Trinidad & Tobago, Romania, Venezuela
5% - 10%	9	14.5%	South Africa, Brazil, Argentina, Hungary, Poland, Mauritius, Latvia, Greece, Czech Republic
10% - 20%	5	8.1%	Chile, Slav Republic, Spain, France, Malaysia
20% - 30%	7	11.3%	Portugal, Italy, Austria, Belgium, Ireland, Taiwan, Germany
30% - 40%	6	9.7%	Japan, United Kingdom, Switzerland, Hong Kong, New Zealand, Finland
40% - 50%	7	11.3%	Korea, Canada, Australia, Netherlands, Singapore, Denmark, Norway
50% - 60%	3	4.8%	Sweden, United States, Iceland
Total	62	100%	

**Table 2. Correlation Matrix**

	DIFF	ITCOST	EFI	INCOME	PC	CELL	TEL	INNOV
DIFF	1.000							
ITCOST	-0.218	1.000						
EFI	-0.718*	0.072	1.000					
INCOME	0.904*	-0.137	-0.803*	1.000				
PC	0.948*	-0.186	-0.752*	0.936*	1.000			
CELL	0.812*	-0.138	-0.762*	0.882*	0.797*	1.000		
TEL	0.886*	-0.187	-0.756*	0.939*	0.895*	0.870	1.000	
INNOV	0.812*	-0.189	-0.665*	0.849*	0.802*	0.767*	0.857*	1.000

\*Significant at the 0.01 level

The regression model (1) was estimated using the Ordinary Least Squares (OLS) technique. As the correlation matrix indicates, there is a strong likelihood of multicollinearity among some of the independent variables. One approach to address this problem is to identify the collinear variables and eliminate them in the model without a specification problem. Thus, to identify such collinear variables, an indicator of multicollinearity, the variance inflation factor (VIF) is used (Myers, 1986). Variance inflation factors indicate the degree to which the variances of the regression coefficient estimates are inflated due to the presence of multicollinearity<sup>1</sup>. As a rule of thumb, if the VIF of an explanatory variable exceeds 10, the variable is considered to be highly collinear and it can be excluded from the regression model (Kleinbaum, et al., 1988). Only one variable (INCOME) had a VIF value that exceeded this threshold (VIF = 14.29) and thus, this variable was excluded from further estimation and analysis. The exclusion makes sense without a specification problem, because theoretically one would expect that in an economy, as the income level increases, the number of telephones, cell phones and personal computers also increase.

Next, a new specification of the regression model (1), without the INCOME variable was undertaken. Table 3 reports the regression results using the Ordinary Least Squares (OLS) estimation technique. Note that only PC is statistically significant at the 0.01 level while ITCOST and CELL are statistically significant at the 0.05 level. Note that the OLS results do not take into account the existence of outlier and/or extreme observations, as it is well known that the presence of such observations can adversely affect the coefficient estimates in regression analysis (Fox, 1997). Furthermore, the nature of the international cross-sectional data used here lends itself to the problem of outliers and extreme observations. Therefore, the results of the re-specified model without the INCOME variable were analyzed for the presence of extreme observations, using such diagnostic measures as DFBETAS, DFFITS and RSTUDENT (Belsley, et al., 1980). Paraguay, Ukraine, Vietnam and Zimbabwe were identified as outliers. Consequently, to adjust for the disproportionate effects of these outliers, a robust estimator, the TUKEY estimator was employed (see Huber, 1981; Judge et al., 1988). This estimation technique produces regression estimates that are insensitive to model specification and data perturbation. The results of the specification using the Tukey estimator are reported in Table 3.

**Table 3. Regression Results**

<u>Dependent Variable</u>	<u>Independent Variables</u>	<u>OLS Coefficient Estimates</u>	<u>Tukey's Coefficient Estimates</u>
DIFF	Constant	0.29	0.20
	ITCOST	-0.25**	-0.16*
	EFI	-0.50	-0.35*
	PC	0.67*	0.66*
	CELL	0.22**	0.20*
	TEL	0.16	0.22*
	INNOV	0.23	0.25*
	R <sup>2</sup>	0.95	

\* Significant at the .01 level; \*\* Significant at the 0.05 level. For OLS coefficient estimates, the significance is evaluated based on the White's heteroscedasticity-consistent standard errors.

<sup>1</sup>  $VIF_j = 1/(1 - R^2_j)$  where  $R^2_j$  is a measure of the degree of multicollinearity between  $X_j$  and other explanatory variables. Therefore, if  $R^2_j = 0$ , then  $VIF_j = 1$ , and if  $R^2_j = 1$ , then  $VIF_j = \infty$ .

Note that now, all regression coefficients display the hypothesized signs with meaningful magnitudes, and are statistically significant at the 0.01 level. Therefore, hypotheses  $H_1$ ,  $H_2$ ,  $H_4$  -  $H_7$  are supported by the empirical evidence and hypothesis  $H_3$  cannot be tested, as variable INCOME was excluded from the analysis due to its collinearity with other predictor variables. In addition, of particular interest is the magnitude and statistical significance of the economic freedom index variable, EFI. The coefficient of the EFI variable (-0.35) indicates that as an economy becomes free and therefore less controlled (low values of EFI), the rate of Internet diffusion, DIFF, increases.

## SUMMARY AND CONCLUSIONS

The results of the empirical analysis presented in this paper indicate that globally, the Internet diffusion rates are determined by such factors as the cost of Internet access, penetration rates of cellular phones, fixed-line phones, and personal computers, innovative capability of the economy, and the extent of economic freedom of the country. While the infrastructure and cost related issues are critical to bridging the global digital divide (as determined by the wide variance in Internet diffusion rates of nations), factors related to the quality of public institutions, and good business and individual governance policies, as reflected by the extent of economic freedom also matter. A strong system of well-defined and enforced property rights and individual and business contracts, which is a hallmark of a country with a high degree of economic freedom, is instrumental in addressing the digital divide issue.

The empirical findings presented in this paper, point out several policy implications for countries that strive to increase the rate of the Internet diffusion. First, adequate human and financial resources need to be ploughed into providing adequate and relevant educational opportunities in many countries. Policies that stimulate and promote innovations and entrepreneurship must be encouraged. Second, the lack of basic technology infrastructure such as access to telephone (voice and data communication) and affordable personal computers or similar devices must be addressed. In this regard, simple and less expensive computers such as "Simputer" (stands for "simple, inexpensive, multilingual computer") developed by a consortium of organizations in India could cost effectively fill the PC gap (Harvey, 2002). Additionally, appropriate proactive policies must be implemented and followed through to address the digital divide issues. Governments, businesses, and international development agencies need concerted and coordinated efforts towards narrowing the existing digital divide gap. In the absence of this, many nations will miss out on the economic benefits of information technology revolution that is sweeping many industries and economies.



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