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Internet Use in Transition Countries
Economic and Institutional Determinants

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Summary

The number of Internet users as percentage of population varies significantly across transition countries. While some transition countries post penetration rates that exceed the performance of Western European laggards, most lag well behind Western European performance. Take-up growth is very rapid in a number of countries but, as the base is very low, convergence, if any, is likely to take some time. Broadly similar stylized facts emerge from a review of the spread of Internet hosts and number of PCs per 100,000 inhabitants.

The paper examines empirically the key economic, social and institutional determinants of Internet usage in transition countries, along the lines of a recent study by Wallstein for the telecom sector[1], and the potential convergence in take-up rates between EU countries and transition countries, and draws major policy lessons for transition countries.

In a first part of the study, α convergence, absolute β convergence and relative β convergence in Internet take-up rates (defined as either the estimated number of users or the number of domain hosts) in EU countries and transition countries will be examined to determine whether a new digital curtain is likely to arise in Europe and stimulate appropriate policy responses. The approach builds on the large empirical economic growth literature and the lessons learnt from this work, but focuses exclusively on the Internet take-up rates.

In the second part, in addition to taking account of typical explanatory variables such as income, education, price, etc the study focuses on the general state of transition and the nature of the Telecom regulatory regime, and competition in the telecom sector (using the telecommunications transition indicators published annually by the EBRD), the state of the Internet supply and the state of the telecom infrastructure and more general policy variables (openness to foreign influences, economic and political freedom, etc.) The purpose of focusing on these additional variables is to identify potential areas for priority action by policy-makers.

The final section brings together the key policy lessons that flow from the empirical results and identifies priority action area for transition countries and the international community.

[1] Scott J, Wallstein, An Econometric Analysis of Telecom Competition, Privatization, and Regulation in Africa and Latin America, The Journal of Industrial Economics, Vol. XLIX, March 2001, No. 1

1. Introduction

Much has already been written in recent years about the so-called "new economy" and the Internet. However, in the economic academic literature, the focus so far has been mainly on the potential impact of ICT (information and communication technologies) in general on output and productivity[3] and to a much lesser extent on the specific economic impact of Internet[4].

Yet, at the policy level, the potential use of ICT and, more particularly, the Internet as an instrument of change, and economic development and growth has attracted considerable attention. Much policy discussion in various international and domestic fora has been devoted to the development of policies promoting the use of the Internet by households, business and governments. Many governments throughout the world have by now adopted explicit policies targeting the domestic development of Internet.

However, the empirical evidence of the determinants of the take up of Internet in various countries is rather limited at the present time. Overall, we are aware so far of only six quantitative multivariate studies examining in detail potential factors explaining the different Internet take-up rates across the world. One study focuses on the OECD countries (Hargittai, 1999), a second one on Africa[5] (Conte, 2000), the third one on Latin

[3] For a good overview of the on-going debate on the likely impact of ICT on productivity see, for example Brynjolfson and Hitt (2000), Gordon (2000), Jorgensen (2001), Kraemer (2001), Nordhaus (2001) and Stiroh (2001).

[4] In fact, the literature on the likely social impact of the Internet, i.e. the debate on the digital divide within countries and among countries, appears to exceed by far the literature on the likely economic impact. For more information on the digital divide issue, see for example Cohen, deLong and Zysman (2001), G7/G8 (2000) and OECD (2001). Litan and Rivlin (2001) provide a good overview of the likely economic impact of the Internet.

[5] A recent study by Onyeiwu (2002) looks more generally at variations in "access to information technology". The latter variable is an index reflecting the number of Internet hosts per 10,000 of the population, the number of Internet users per 10,000 of the population, the number of personal computers

America (Estache et al., 2002)[6], two on a number of developing countries (Dasgupta, 2001[5], Wallsten, 2002) and one on Internet use by businesses in Central and Eastern Europe (Clarke, 2002).

In the present study, we seek to expand the current stock of knowledge on the determinants of Internet use by focusing on developments in Central and Eastern Europe and the key factors driving these developments.[7] We also provide a comparison with developments in the European Union as, at least for the EU accession countries in Central and South Eastern Europe, such developments implicitly set benchmark targets that would need to be met if a digital curtain is to be avoided in the coming years between the present and future members of the European Union.

Section 2 provides a few stylised facts about Internet use in Central and Eastern Europe and the European Union. Section 3 examines whether some convergence in Internet usage is observable across the geographical zone covered by our study. The existing literature on the determinants of Internet use is summarised in Section 4. Section 5 discusses a simple model of Internet usage and presents the estimation results of this model for the period 1995-2000 and a few sub-periods. In Section 6, we expand the previous model into a three equations model of the number of personal computers in a country, the number of Internet hosts and the number of Internet users, and report the results of its estimation for the year 2001, the first year for which Internet user costs information is provided by the ITU. Finally, some policy observations and concluding remarks are offered in Section 7.

2. Internet Use in Central and Eastern Europe and the European Union – Some key facts

A key issue faced by any study of Internet usage is how to define this usage. In practice, two measures are generally used, namely the number of Internet hosts and the number of Internet users. Ideally, one would want to use the latter measure. However, in reality this measure suffers from a high degree of imprecision, as it is often no more than a rough guess estimate.

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per 100 of the population, the number of telephone lines per 100 of the population and the number of cellular phones per 100 of the population.

[6] Although the paper also provides estimation results of a model of Internet-use worldwide, its primary focus is on Latin America.

[7] This present report is part of a broader examination of Internet usage in Central and Eastern Europe.

On the other hand, the number of Internet hosts is likely to be a somewhat biased measure of real Internet use as the correlation between real Internet use and number of Internet users is less than one, especially in emerging and developing economies (Figure 1).

Moreover, the link between a host's domain and its physical location is not necessarily very tight. For example, domains such as edu/org/net/com/int could be located anywhere. The bottom line is that, at the present time, there exists no perfect measure of Internet usage[8] and we will use the number of Internet hosts, as published by the ITU[9]. In the present study, we will focus primarily on the determinants of the number of Internet hosts.

In the geographical area covered by our study, the number of Internet hosts (per 10,000 inhabitants) ranged in 2001 from 0.08 in Uzbekistan to 1707 in Finland. For comparison, this figure stood at 3714 in the USA in 2001. As Table 1 shows, this aggregate picture hides significant regional differences in terms of both average number of Internet hosts within sub-regional groupings and differences among countries in these sub-groupings. Not surprisingly, Internet usage is markedly more developed in the EU than in the other two regional sub-groups.

Moreover, while considerably lower than in the EU, Internet usage in the Central and South-eastern European EU accession countries is nevertheless much higher than in the C.I.S[10] and South-eastern European non-EU accession countries.

For example, in 2001, the average number of hosts (per 10,000 inhabitants) stood at 535 in the European Union, while the Central and South Eastern European EU accession countries averaged only 95 hosts (per 10,000 inhabitants) and the C.I.S. and South Eastern non EU-accession countries posted an average of only 9 hosts.

In addition, the C.I.S. and South-eastern European non-EU accession countries recorded a variation in the number of Internet hosts among them that is practically twice as large as that of the Central and South Eastern European EU accession countries. The latter appear to be significantly more homogeneous in their Internet usage (as proxied by the number of Internet hosts) than even the current EU members.

A broadly similar picture emerges from the data on the number of Internet users with two key differences. First, the difference between present EU members and Central and South Eastern European EU accession countries is much less pronounced. Second, the

[8] For more details on measurement issues of Internet access and usage, see Minges (2001).

[9] See for example ITU (2001) and ITU (2002). In the ITU databank, the Internet hosts measure is a count of the computers that are directly connected to the worldwide Internet network and the statistic is based on the country code in the host addresses.

[10] Commonwealth of Independent States (former U.S.S.R.).

present EU is the sub-regional grouping that is the most homogenous on the basis of this proxy of Internet usage.

Finally, it is worth noting that the ratio of the number of Internet users to the number of Internet hosts varies considerably, ranging from 5.9 in the EU to 19.5 in the C.I.S. and South-eastern European non EU-accession countries.

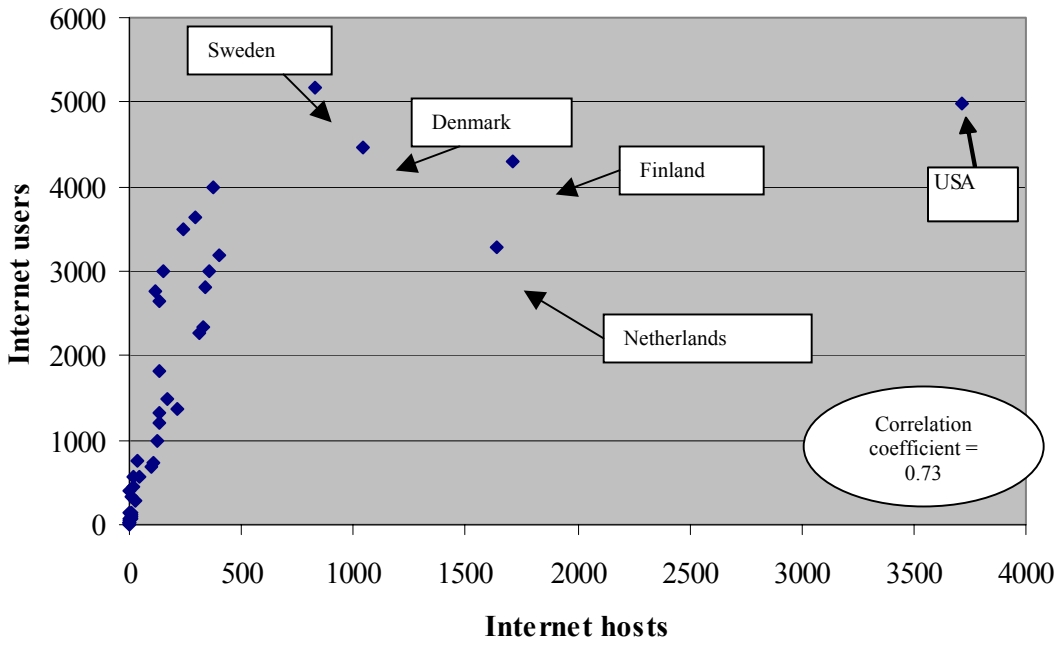
In fact, the correlation between these two proxies of Internet usage is only 0.73 in 2001 in the geographical zone covered by the study. The existence of only a limited correlation is further illustrated by Figure 1, which plots the number of Internet users (per 10,000 habitants) against the number of Internet hosts (per 10,000 habitants).

Table 1
Key facts about Internet Usage in the European Union and Central and Eastern Europe in 2001
(per 10,000 inhabitants)

	All Countries	**EU**	**EU Accession Countries in Central Europe (2)**		**CIS and South Eastern Europe (3)**	
Internet usage proxy						
Internet hosts				*Index, EU average = 100*		*Index, EU average = 100*
Average	239	535	140	*26.2*	9	*1.8*
Normalized standard deviation (1)	2.78	0.98	0.68	*0.69*	1.28	*1.31*
Minimum	0.08	117	21	..	0.08	..
Maximum	1707	1707	357	..	47	..
Internet Users						
Average	1562	3166	1364	*43.1*	182	*5.76*
Normalized standard deviation	0.98	0.33	0.67	*2.03*	1.04	*3.15*
Minimum	5	1321	447	..	5	..
Maximum	5163	5163	3008	..	562	..
Ratio of Internet users to Internet hosts	6.5	5.9	9.7	*1.6*	19.5	*3.3*

Source: ITU (2002)
(1) = standard deviation divided by average
(2) = including Bulgaria and Romania
(3) = excluding Bulgaria and Romania

Figure 1
Number of Internet hosts and users in the European Union and Central and Eastern Europe
(per 10,000 inhabitants)



Source: ITU (2002)

3. Is Internet Usage Converging in the EU and Central and Eastern Europe?

As a first step in our analysis of developments in Internet usage across the EU and Central and Eastern Europe, we examine whether Internet usage shows a tendency to converge in the geographical zone of interest[11]. As the Internet is still a relatively young phenomenon and started to take off only around 1993[12], we focus our analysis on the

[11] The countries included in this analysis are the EU and Central and Eastern Europe except Bosnia and Herzegovina, Moldova and the FYR Yugoslavia. Only incomplete data are available for these countries.

[12] For a detailed overview of initial Internet developments see, for example, Werle (2001).

period of 1995 to 2001. By 1995, Internet usage had already started to develop rapidly in the USA and some European countries such as Finland.

We consider both β convergence and σ convergence. The latter convergence statistic is simply the standard deviation of Internet usage across countries in a given year and its change over time describes the evolution of the distribution of Internet usage of the entire group of countries[13].

In contrast, β convergence reflects the movement of individual countries within a group. The hypothesis that is tested is whether countries that exhibited low Internet usage in 1995 post faster growth in Internet usage over the period of 1995 to 2001 than those countries that exhibited higher Internet usage in 1995. Empirically, this hypothesis is tested by estimating equation (1) below and detailed estimation results are reported in Table 3.

(1) $\gamma_{i,\,1995,2001} = \alpha - \beta * \log(y_{i,\,1995}) + \varepsilon_{i,\,2001}$ where

$\gamma_{i,\,1995,2001}$ is equal to $\log(y_{i,\,2001}/\, y_{i,\,1995})^{(1/6)}$

The detailed estimated σ convergence and β convergence statistics[14] are reported in Tables 2 and 3. First, the results of the σ convergence analysis show that:

i. With the exception of 2001, the distribution of Internet usage across all the countries in our sample tends to become slowly more homogeneous, although the intra-sample variation remains still very large. By 2001, this statistic stands at 1.64. In other words, the annual standard deviation of Internet hosts, on a per capita basis, stands at 1.64, donw from 2.09 in 1995.

ii. The EU countries also show a narrowing of the differences across countries in Internet usage, although some reversal is observable in 2000 and 2001;

iii. Moreover, the EU countries post much smaller inter-country differences than the Central and Eastern European countries (σ of 0.99 versus σ of 1.41); and,

iv. Central and Eastern European countries show no sign of substantial σ convergence of the period 1995 to 2001.

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[13] Because the number of Internet hosts, on a per capita basis, is growing rapidly over the period of 1995 to 2001, we present the normalised standard deviation, i.e. the annual standard deviation divided by the annual average.

[14] The STATA software package was used to estimate equation (1).

Second, the results of the β convergence also show slow absolute convergence for all three samples of countries (all countries, the EU countries and Central and Eastern European countries). Across all the countries in our sample, the average annual growth rate of Internet usage (as proxied by the number of Internet hosts on per capita basis) over the period 1995 to 2001 is, on average, 0.41% lower for each ten percentage-points higher Internet usage in 1995. Of note is the fact that the EU countries show a convergence rate that is about 20% higher than the convergence rate posted by Central and Eastern European countries (-0.047 versus -0.039).

Table 2
σ Convergence[1]: Number Of Internet Hosts Per Capita
1995-2001

	1995	1996	1997	1998	1999	2000	2001
All countries	2.09	1.88	1.97	1.61	1.47	1.47	1.64
EU countries	1.32	1.18	1.21	0.92	0.78	0.86	0.99
Central and Eastern Europe	1.58	1.56	1.64	1.57	1.51	1.39	1.41

(1) σ convergence = normalised standard deviation of log of y_i, where y = number of Internet hosts per capita and i = country i
Source: ITU (2001)

Table 3
Absolute β Convergence – Number of Internet Hosts Per Capita
1995-2001

$$\gamma_{i,\,1995,2001} = \alpha - \beta * \log(y_{i,\,1995}) + \varepsilon_{i,\,2001}$$

(t- statistic in parenthesis)

	All countries	EU	Non-EU
α	0.323 (9.93)	0.313 (13.99)	0.340 (4.37)
β	-0.041 (5.44)	-0.047 (2.84)	-0.039 (2.72)
Adj. R^2	0.45	0.38	0.28
RMSE	0.13	0.07	0.16

$\gamma_{i,\,1995,2001} = \log (y_{i,\,2001}/ y_{i,\,1995})^{(1/6)}$ and y_i = number of Internet hosts per capita in country i
Source: ITU (2001)

4. Overview of the Literature of the Determinants of Internet Usage

A survey of previous studies of the factors (see Table 4 for a summary overview) explaining the variation in Internet usage across countries shows that it is generally closely related to a country's income (GDP per capita or a similar measure).

Other socio-economic factors that have been conjectured as playing a role are the size of the population, income inequality, the overall education level of the population, the relative size of the urban population although the empirical estimates do not so far provide strong evidence that these are major factors.

However, a country's openness (trade, FDI, etc) to other countries is a robust predictor of Internet penetration, especially in the emerging and developing countries.

The state and quality of the overall telecommunications infrastructure is also often viewed as a key factor explaining different Internet take-up rates across countries. According to some studies, the number of telephone lines and the cost of local calls appear to be a relevant factor.

The degree of competition in the telecommunications sector also appears to play a critical role. This is not surprising in light of the more general literature on telecommunications that finds generally a solid link between the level of development of telecommunications and competition in the sector.[15]

In line with standard consumer demand, the costs of Internet access are also often expected to be a key determinant of Internet usage. However, as the Internet costs data are very limited, especially for non-OECD countries, this hypothesis has not yet been robustly tested.

Finally, some authors have also used the number of personal computers in a country as a determinant of Internet usage. The use of such a variable, however, can be problematic as it is not a priori obvious which variable is the truly exogenous one. In the case of countries having taken to the Internet only more recently, it is possible that, in fact, it is the availability of Internet that determines the decision to acquire a personal computer and that, hence, the causality is reversed.

[15] See for example Spiller and Cardilli (1997) and Wallsten (2001).

Table 4
Key Determinants of Internet Usage in Previous Studies
(Only statistically significant variables are reported)

	Study					
	Clarke (2002)[(1)]	**Conte (2000)**	**Dasgupta et al. (2000)**	**Estache et al. (2001)**	**Hargittai (1999)**	**Wallsten (2002)**
	Eastern Europe and Central Asia	Africa	Number of developing countries in Africa, Asia and Latin America	Latin America	Western Europe	Number of developing, emerging economies and transition economies
Dependent variables	Probability that an enterprise has access to the Internet	Number of Internet accounts	Growth in Internet usage, 1990 to 1997 (Internet subscribers and Internet hosts)	Number of Internet users	Number of Internet hosts	Number of Internet users/hosts
Explanatory variables						
Socio-Economic						
GDP or GDP per capita	x			x	x	x
Population	x	x				
Urban population	x		x			
Income distribution				x		
The economy's openness						
Trade (imports)	x	x				x
FDI						
Education						
State of telecommunications infrastructure						
Number of telephone lines	x	x			x	x
Costs of a local call		x				
Competition in the telecommunication sector						
Monopoly provider					x	
Nature of regulation/competition			x			x
Privatisation of incumbent						x
Internet factors						
Internet costs						
Number of PCs					x	x
ISP regulation						x

(1) Only country specific factors are reported in the table

5. Explaining Variations in Internet Usage over the Period 1995 – 2000: A Simple Model

Our basic model of the determinants of Internet usages starts from the existing literature. It includes a number of socio-economic indicators (X1), a number of indicators of the state of telecommunications infrastructure (X2), an indicator of the state of competition in the telecommunications sectors (X3) and two dummy variables indicating whether the country is a EU accession country (acc) or non-EU accession country in Central and Eastern Europe (not)[16][17].

Essentially, the basic model is given by equation (2):

$$(2)\quad Y_{t,i} = \alpha + \sum\beta 1_j\, X1_{j,t,i} + \sum\beta 2_j\, X2_{j,t,i} + \sum\beta 3_j\, X3_{j,t,i} + \delta_1\, acc + \delta_2\, not + \varepsilon_{t,i}$$

Where:

- the set of X1 variables comprises GDP per capita (gdpc2), the Human Development Indicator education index (edu) and imports of goods and services as % of GDP (mgdp2);

- the set of X2 variables includes the number of telephones lines per 100 habitants (lines), the cost of a local call as a percentage of daily GDP per capita (cost2) and the cost of a monthly residential telephone subscription as a percentage of monthly GDP per capita (subsgdp2); and

- X3 is initially proxied by the number of cellular phone subscribers per 100 habitants (celsubs). The rational for using such a proxy in the absence of any other data is the fact that the economic literature generally shows that a competitive and well regulated telecommunications sector is conducive to rapid growth in cellular phone usage; and,

- $Y_{t,I}$ = the number of Internet hosts on a per capita basis.

The precise data definitions and data sources are provided in Annex 1. All the non-dummy variables are used in logarithmic form[18] in the models whose estimation results are reported in this paper.

[16] In addition, fixed years effects are included in the model.

[17] A major missing explanatory variable is the cost of Internet access. Due to the absence of consistent Internet cost or price data, this variable is presently omitted from the model. As the ITU has started to publish such data, it is hoped that it will be soon feasible to incorporate a price/cost measure in the model.

[18] The names of the variables that are used in log from are prefixed with a "l".

The model given by equation (2) is first estimated for all countries in our sample over the period 1995 to 2000 (Model 1 in Annex 1). The same model is then re-estimated for the Central and Eastern European countries over the same period.

Because, the local telephone call cost variable is not available for a number of Central and Eastern European countries, including Russia, the same model without the local telephone cost variable is re-estimated for all countries (Model 2) and the Central and Eastern European countries only.

This modified basic model is then re-estimated for the period 1998-2000 only for all the countries in our sample (Model 3) and the Central and Eastern European countries only.

The reason for re-estimating the basic model over a shorter period is that we wish to test whether the more refined indicators of the state of transition of the telecommunications sector in Central and Eastern Europe produced by the EBRD (see Annex 1 for details) would help provide more directly-derived and robust estimates of the impact of the competition and regulation on Internet take-up rates (Model 5)[19].

An alternative version of model 3 tests whether differences in political freedom and civil liberties across countries, as reflected by the freedom indicators produced annually by Freedom House, contribute to explain differences in Internet usages. The underlying hypothesis is that more repressive political regimes explicitly or implicitly limit the spread and use of Internet (Model 4).

Finally, the last model (Model 6) includes both the transition and the freedom indicators. Models 4,5,6, are estimated only the sub-sample of Central and Eastern European countries.

The detailed estimation results[20] for models 1 to 6 are provided in Annex 1 and, to facilitate their analysis, are summarized in Table 5[21].

[19] A recent paper by Piatkowski (2002) provides a good overview of the level of preparedness of transition economies to harness the potential of ICT. Unfortunately, no time series data are provided in the study and thus we were unable to use that information.

[20] All models are estimated with the STATA package.

[21] All non-dummy variables are prefixed with the letter l because they are used in log form in the models that are being estimated.

Table 5
Summary of Estimation Results:
Sign of Estimated Coefficient and Statistical Significance
Dependent variable = number of Internet hosts per capita

	Model								
	1		2		3		4	5	6
Country sample	**A**	**B**	**A**	**B**	**A**	**B**	**B**	**B**	**B**
Explanatory variable									
X1 variables									
lgdpc2	+**	+**	+**	+**	+**	+**	+**	+**	+**
lmgdpc2	+**	+**	+**	+**	+**	+**	+**	+**	+**
ledu	+**	-*	+**	..	+**	..	+**	+	+**
X2 variables									
llines	..	+**	+	+**	+*	+*	..	..	..
lcost2	..	..	/	/	/	/	/	/	/
lsubsgdp2	+*	+**	+	+**	+*	+**	+*	+	+
X3 variables									
lcelsubs	+**	+**	+**	+**	+*	+**	+*	+**	+*
EBRD indicator 23	/	/	/	/	/	/	/	..	..
EBRD indicator 34	/	/	/	/	/	/	/	+*	+
Free and partially free dummy	/	/	/	/	/	/	+**	/	+**
acc dummy	+**	/	+**	/	+**	/	+**	..	..
not dummy	..	-**	+	-**	..	-*	/	/	/
Adj. R^2	0.8567	0.8898	0.8756	0.8786	0.8419	0.8722	0.9032	0.8787	0.9209

Table legends: A = all countries; B = only Central and Eastern European countries. See text for definitions of models 1 to 6 and Annex 2 for precise data definitions; models 1 to 2 are estimated over the period 1995-2000 while models 3 to 6 are estimated over the period 1998 -2000.
+ = positive coefficient, - = negative coefficient;
** = statistically significant at 5%, * = statistically significant at 10%, no * = statistically significant at 20%, .. = statistically insignificant, / = variable not used in the model

Overall, the explanatory power of the various models is relatively high with an adjusted R^2 ranging from 0.88 to 0.92 depending on the model. The key estimation results to note are the following:

i. Income or GDP per capita (lgdpc2) is a key a factor explaining variation in Internet use. This variable is always statistically significant and the estimated Internet usage elasticity to per capita income ranges from 1.1 to 0.7, depending on the estimation period and the model (see Annex 2 for details). Of particular interest is fact that the more elaborate models show an elasticity of about 0.7 to 0.8 over the period 1998-2000;

ii. Openness to foreign influences, as proxied by the ratio of imports of goods and services (lmgdpc2), is also a critical factor. In fact, in the case of the Central and Eastern European countries, Internet usage is somewhat more sensitive to openness than to GDP per capita over the period 1998-2000. For example, in model 6, the most comprehensive model, Internet usage increase by 0.95 percentage point for each percentage point increase in the ratio of imports of goods and services while a one percentage point rise in per capita GDP increases Internet usage by 0.84 percentage point;

iii. Education (ledu) is generally statistically significant. It is always for the full sample of countries and it is statistically significant in the case of Central and European countries once the freedom and telecommunications indicators are included in the model.

iv. Phone density, proxied by the number of lines per 100 habitants (llines), is a statistically significant factor only in the models focusing only on Central and Eastern Europe and only when no special variables measuring the state of liberalisation of the telecommunications or political and civil freedom are included;

v. The costs of a local call (lcostpc2) is not statistically significant;

vi. In contrast, the cost of a monthly residential subscription (lsubsgdp2) is generally highly significant. However, the sign of the estimated coefficient is positive rather than negative. This suggests that telephone usage and Internet usage are either substitutes, a doubtful proposition, or this variable captures the influence of other omitted variables. This puzzling result will require further investigation in future work.

vii. The number of cellular phone subscribers (lcelsubs) is always statistically significant (and the coefficient is positive), even in the models introducing explicit measures of the state of liberalization of the telecommunication sector. This suggests that this variable does more than simply proxying the state of deregulation and competition in the telecommunications sector. It may capture

more generally the overall dynamism of the telecommunications sector, which, in turn, may stimulate Internet supply and hence raise Internet usage rates. This is another area that warrants further research.

viii. The freedom variable (free) is highly significant Countries that are free or partially free according to the Freedom House indicators, experience significantly higher Internet usage – the semi-elasticity of Internet usage to this dummy is 1.3;

ix. The state of transition of the telecom sector towards a full liberalization (ind23,ind34) matters also, but only when a high degree of liberalization (ind34) has been achieved – the equivalent of a rating of 3+ and more on the scale of the EBRD transition ratings. Quantitatively, with a semi-elasticity of about .7 to .9, this latter factor is significant as well, albeit somewhat less than the freedom variable.

x. Everything being equal, countries that are free and fairly advanced in their transition to full telecommunications liberalisation post an Internet usage that is 2.0 percentage point higher;

xi. When all countries are included in the sample, the EU Accession country dummy (acc) is always statistically significant while the dummy of the non-EU accession countries in Central and Eastern Europe (not) is never statistically significant. As the constant term implicitly captures the state of being a EU country, the estimation results suggest that Internet usage in the EU Accession countries (relative to Internet usage in the EU and non-EU Accession countries) is higher than suggested by the socio-economic and telecommunications variables included in the model.

xii. Similarly, in the less refined models focusing only on Central and Eastern European countries, the EU Accession countries always post an Internet usage that, with identical socio-economic and telecommunications sector conditions, is higher than in the non-EU Accession countries. However, once the state of transition towards a liberalised telecommunications sector (ind23, ind34) is introduced explicitly in the model, the accession country dummy is no longer significant.

In short, the estimation results show that differences in Internet usage across Central and Eastern Europe over the period 1998 to 2000 are largely explainable by:

- differences in income per capita;
- the economy's openness to foreign trade;
- the education level;

- the number of cellular phone subscribers;
- the cost of a monthly residential phone subscription;
- the state of political and civil freedoms; and,
- the state of transition of the telecommunications sector towards a fully liberalized sector.

6. Explaining Variations in Internet Usage in 2001 – A Three Equations Model

In this section, we expand the findings of the previous section by providing the cross-section estimation results of a three variables model that seeks to explain variations in the number Internet hosts, the number of personal computers across countries and the number of Internet users. The purpose of this model is to examine the causal links between these three variables, in particular whether there exist any causal relationships running from the number of Internet hosts or Internet users to the number of personal computers.

The list of explanatory variables is broadly similar to those used in the simple single equation model discussed in the previous section. The set of explanatory variables comprises a number of socio-economic indicators (X1), a number of indicators of the state of telecommunications infrastructure (X2), an indicator of the state of competition in the telecommunications sectors (X3), a number of Internet specific factors (X4), two dummy variables indicating whether the country is a EU accession country (acc) or a non-EU accession transition country in Central and Eastern Europe (not), dummy variables reflecting the state of political and economic freedoms in the country (dfree) and dummy variables reflecting the state of transition of the telecommunications infrastructure (indi). In addition, we make use of the recently released information on Internet user costs.

Moreover, the equation of each of the three target variables includes the two other target variables as explanatory variables.

Essentially, the basic model is given by the system of equations (3) to (5):

(3) $Y1_{t,i} = \alpha\ 1+\sum\beta11_j\ X1_{j,t,i} + \sum\beta12_j\ X2_{j,t,i} + \sum\beta13_j\ X3_{j,t,i} + \sum\beta14_j\ X4_{j,t,i}+\delta1_1$ acc $+ \delta1_2$ not $+ \delta1_3$ dfree3 $+ \delta1_4$ dindi56$+ \delta1_5$ dindi78$+ \tau1_1 * Y2_{t,i} + \tau1_2 * Y3_{t,i} + \varepsilon1_{t,i}$

(4) $Y2_{t,i} = \alpha\ 2+\sum\beta21_j\ X1_{j,t,i} + \sum\beta22_j\ X2_{j,t,i} + \sum\beta23_j\ X3_{j,t,i} + \sum\beta24_j\ X4_{j,t,i}+\delta2_1$ acc $+ \delta2_2$ not $+ \delta2_3$ dfree3 $+ \delta2_4$ dindi56$+ \delta2_5$ dindi78$+ \tau2_1 * Y1_{t,i} + \tau2_2 * Y3_{t,i} + \varepsilon2_{t,i}$

(5) $Y3_{t,i} = \alpha 3 + \sum\beta 31_j \; X1_{j,t,i} + \sum\beta 32_j \; X2_{j,t,i} + \sum\beta 33_j \; X3_{j,t,i} + \sum\beta 34_j \; X4_{j,t,i} + \delta 3_1$ acc + $\delta 3_2$ not + $\delta 3_3$ dfree3 + $\delta 3_4$ dindi56+ $\delta 3_5$ dindi78+ $\tau 3_1 * Y1_{t,i} + \tau 3_2 * Y3_{t,i} + \varepsilon 3_{t,i}$

Where: $Y1_{t,i}$ = number of personal computers per capita, $Y2_{t,i}$ = number of Internet hosts per hundred of inhabitants and $Y3_{t,}$ = number of Internet users per hundred of inhabitants

The model was estimated using the two-stage least squares technique. In order to be able to identify each equation, different explanatory variables were dropped in each of the equations. The estimation results of this general model are reported in Table 6 overleaf. The key point to note at this stage is that, because of multicollinearity, very few explanatory variables appear to have any significant explanatory power.[22]

Table 6
Summary of Estimation Results of Three Equations Model - 2001
Sign of Estimated Coefficient and Statistical Significance
(Results of two-stage least-squares estimation)

	General Model			Parsimonious Model		
Dependent variables[1]	**Hosts**	**PCs**	**Users**	**Hosts**	**PCs**	**Users**
Explanatory variables[1]						
hosts	--	+	--	--		
Pcs	+	--	+	+***		+***
users	-	+	--	--		
GNI	--	+***	--	-***	+***	
imp	-	+	-	--	+***	
edu	+	+	+	--	+***	
lines	+	--	+**	+***	+**	+***
celsubs	--	+	+	--		
dindi56	-	+	-**	-***		-***
dindi78	-	--	-	--		
x1	+	-	+*	+***		
x2	--	-	-	--		
dfree2	--	--	--	--		
dfree3	-	+	--	--		
acc	-	+*	+	--	+***	
not	-	+	-	--	+***	-***
Constant	--	-	-	-	-	-
"R^2"	0.900	0.9710	0.966	0.936	0.963	0.946
F-stat	13.53	46.77	45.71	70.08	98.40	109.01
Rmse	0.7369	0.3039	0.3039	0.4990	0.2636	0.3229

(1) All variables except dummy variables (dfree and dindi) are expressed in logarithm.
(2) *** = coefficient significant at 5%, ** = coefficient significant at 10%, -- variable not used

[22] The detailed estimation results are provided at Annex 4.

We then proceeded to eliminate stepwise the least significant variables until we arrived at a parsimonious model. This parsimonious model shows a number of interesting features that we present in greater detail below.

The relationship between the number of personal computers and the number of Internet users and Internet hosts[23] is clearly triangular, with variations in the number of personal computers in a country being a key factor explaining variations in the number of both Internet hosts and users, and no feedback causality from the number of Internet hosts and users to the number of personal computers;

The socio-economic variables, such as income, education, openness, that are traditionally used to explain cross-country variations in Internet usage are only key drivers of the number of personal computers in a country, and do not affect the number of Internet hosts and users. The only exception is the gross national income per capita variable. The latter does not only affect the number of personal computers in a country, but also the number of Internet hosts.

However, the number of telephone lines and the state of telecommunication liberalisation have a strong impact on both the number of Internet hosts and users while they do no affect the number of personal computers.

The variable that we used to proxy for the overall state of development of the telecommunications sector is statistically significant only in the equation explaining variations in the number of personal computers across countries.

In essence, the estimation results suggest that socio-economic variables affect mainly the number of personal computers in a country. And, the latter variable together with the number of telephone lines and the state of liberalisation of the telecommunications sector determines the number of Internet hosts and users (See Figure 2overleaf)

[23] These three variables are normalised per 100 habitants but for simplicity we do not repeat this fact throughout the discussion of the results.

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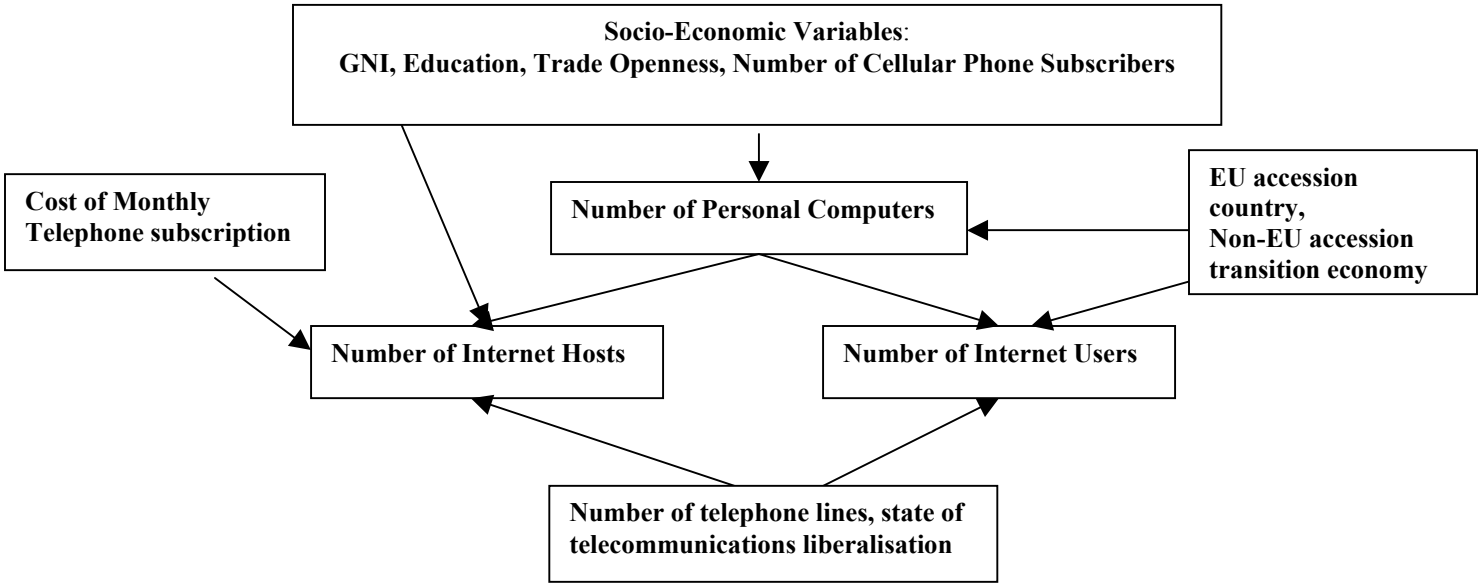
Figure 2
Causal Links in Parsimonious Three-Equations Model



Everything else being equal, economies with less than full-liberalised telecommunications regimes will have fewer Internet hosts and users.

On the other hand, everything else being equal again, accession countries and non-accession transition economies have more personal computers than EU countries. This suggests that the spread of personal computers in these economies is advancing more rapidly that one might have expected on the basis of their socio-economic characteristics and previous experience of the European Union.

The accession country dummy is not statistically significant in the Internet hosts and Internet users equations. This suggests that, in 2001, the number of such Internet hosts and users in these countries is about in line with the degree of spread of personal computers and state of the telecommunications sector (number of lines and degree of liberalisation). However, the coefficient of the dummy for non-EU-accession transition economies is negative and statistically significant in the Internet users equation suggesting that take-up of Internet in these countries is below what one would have expected on the basis of their socio-economic characteristics and state of the telecommunications sector.

Finally, it is interesting to note that the cost of Internet usage is not included as explanatory variable in the parsimonious model as the variable was never found to be statistically significant in explaining variations across countries in the number of Internet users, Internet hosts and number of personal computers.

Finally, to illustrate the impact on the number of personal computers, Internet hosts and Internet users of the various explanatory variables in the parsimonious model, we report below the percentage change in each of three variables resulting from a one-percentage point increase in the key explanatory variables. We also report the estimated impact of full liberalization of the telecommunication sector.

The results in Table 7 below show that the physical infrastructure of the telecommunications, as reflected by the number of telephone lines, has the largest immediate effect on the depth of Internet usage. For example a one-percentage increase in the number of telephone lines per 100 habitants in a country would increase the number of Internet users per 100 habitants by 0.75% and Internet hosts per 100 habitants by 0.80%. This is about twice the effect a percentage-point increase in the level of Gni would have on the same variables. The impact of full liberalisation of the telecommunications sector is about twice as important in the case of the number of Internet hosts as in the case of the number of Internet hosts.

Table 7
Impact On The Number Of Personal Computers, Internet Hosts And Internet Users Of A One-Percentage Point Increase In Key Explanatory Variables

	Explanatory Variable				
Percentage change in the following target variables					
	Gni	**Import Ratio**	**Number Of Cellular Phone Subscribers**	**Number Of Telephone Lines**	**Full Liberalization Of The Telecommunications Sector[1]**
Number of personal computers	0.81	0.25	0.20	--	--
Number of Internet hosts	0.41	0.29	0.23	0.80	0.54
Number of Internet Users	0.40	0.12	0.10	0.75	0.29

(1) In the case of the telecommunications liberalization dummy, the figures reported in Table 7 show the percentage change in the target variable that would arise if the dummy variable dindi56 were set to zero.

7. Conclusion

The results presented in this study are broadly consistent with those reported in previous multivariate studies of the determinants of Internet usage in other parts of the world.

As noted above, in the single equation model focusing on the number of Internet hosts, income per capita, openness, education, political and civil freedoms, the state of transition towards a liberalized telecommunications regime, the state of the telecommunications sector's infrastructure, and the cost of telephone subscriptions are the key variables that explain the variation in Internet usage in the European Union and in Central and Eastern Europe.

The estimation results of the three equations model of the number of personal computers in a country, the number of Internet hosts and the number of Internet hosts, however, suggest that most of the socio-economic variables explain mainly variations in the number of personal computers in a country and that the latter variable is a key factor explaining variations in the number of Internet hosts and Internet users. In addition to variations in the number of personal computers, variations in the number of telephone lines and the state of telecommunications transition are the key factors explaining cross-country differences in the number of Internet users and hosts.

Finally, it is worth noting that Internet usage costs do not appear to explain cross-country differences in the number of Internet hosts and users in our sample of countries. This is an issue that warrants further investigation.

The estimation results also suggest that further research is required to unravel the puzzle of the statistically significant positive coefficient of the monthly telephone subscription price and precise role played by the number of cellular phone subscribers in models aiming to explain why Internet usage varies across countries.

Finally, an additional strand of required research is to further refine the use of indicators of the liberalization of the telecommunications sector by including explicitly variables related to structure of the Internet service providers markets (number of providers, role of incumbent telecommunications operator, regulatory approach to provision of Internet services, etc).

ANNEX 1

DATA DEFINITIONS AND DATA SOURCES FOR MODEL ESTIMATED OVER 1995-2000		
Variable name	**Variable definition**	**Data source**
lgdpc2	Log of GDP per capita in US$	GDP in US$ and population from ITU
limp	Log of imports of goods and services (in US$) as % of GDP (in US$)	Imports of goods and services from WTO and GDP from ITU
ledu	Log of education index	Human Development Report, various issues, UNDP
llines	Number of main lines per 100 habitants	ITU
lfaults2	Log of number of telephone faults per 100 main lines	ITU
lcelsubs	Log of cellular subscribers per 100 inhabitants	ITU
lcost2	Log of cost of three minute local call in US$ as percentage of daily per capita GDP in US$	Cost of local call and GDP from ITU
Lsubsgdp2	Log of monthly residential telephone subscription in US$ as percentage of monthly per capita GDP in US$	Subscription and GDP from ITU
lcelsub	Log of number of cellular subscribers per 100 habitants	ITU
lhostp	Log of Internet hosts per 100 habitants	ITU
dfree1	Dummy variable = 1 when country is free and 0 otherwise	Freedom House
dfree2	Dummy variable = 1 when country is partially free and 0 otherwise	Freedom House
dind3	Dummny variable = 1 when EBRD telecommunications transition indicator is 2 and 0 otherwise	EBRD see Box below
dind4	Dummny variable = 1 when EBRD telecommunications transition indicator is 2+ and 0 otherwise	EBRD see Box below
dind5	Dummny variable = 1 when EBRD telecommunications transition indicator is 3 and 0 otherwise	EBRD see Box below
dind6	Dummny variable = 1 when EBRD telecommunications transition indicator is 3+ and 0 otherwise	EBRD see Box 3 below
dind7	Dummny variable = 1 when EBRD telecommunications transition indicator is 4 and 0 otherwise	EBRD see Box below
dind8	Dummny variable = 1 when EBRD telecommunications transition indicator is 4+ and 0 otherwise	EBRD see Box below
dind56	Dummy variable = 1 when EBRD telecommunications transition indicator is 3 or 3+ and 0 otherwise	EBRD see Box below
dind78	Dummy variable = 1 when EBRD telecommunications transition indicator is 4 or 4+ and 0 otherwise	EBRD see Box below

EBRD Telecommunications Transition Indicators

Rating = 1
Little progress has been achieved in commercialisation and regulation. There is a minimal degree of private sector involvement. Strong political interference takes place in management decisions. There is a lack of cost-effective tariff-setting principles, with extensive cross-subsidisation. Few other institutional reforms to encourage liberalisation are envisaged, even for mobile phones and value-added services.

Rating = 2
Modest progress has been achieved in commercialisation. Corporatisation of the dominant operator has taken place and there is some separation of operation from public sector governance, but tariffs are still politically set.

Rating = 3
Substantial progress has been achieved in commercialisation and regulation. There is full separation of telecommunications from postal services, with a reduction in the extent of cross-subsidisation. Some liberalisation has taken place in the mobile segment and in value-added services.

Rating = 4
Complete commercialisation (including privatisation of the dominant operator) and comprehensive regulatory and institutional reforms have been achieved. There is extensive liberalisation of entry.

Rating = 4+
Implementation of an effective regulation (including the operation of an independent regulator) has been achieved, with a coherent regulatory and institutional framework to deal with tariffs, interconnection rules, licensing, concession fees and spectrum allocation. There is a consumer ombudsman function.

Source: EBRD (2001)

ANNEX 2
ESTIMATION RESULTS OF SIMPLE MODEL OVER 1995-2000

MODEL 1 PANEL 1995 – 2000

ALL COUNTRIES

```
      Source |       SS       df       MS              Number of obs =     196
-------------+------------------------------           F( 14,   181) =   84.26
       Model |  964.066053    14   68.861861           Prob > F      =  0.0000
    Residual |  147.915079   181  .817210383           R-squared     =  0.8670
-------------+------------------------------           Adj R-squared =  0.8567
       Total |  1111.98113   195  5.70246735           Root MSE      =    .904

------------------------------------------------------------------------------
     lhostsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lgdpc2 |   1.117602    .154955     7.21   0.000     .8118519    1.423353
      lmgdp2 |   .4925593   .1768933     2.78   0.006     .1435211    .8415975
      llines |   .2637493   .2448436     1.08   0.283    -.2193656    .7468642
    lcelsubs |   .2443496   .0659926     3.70   0.000     .1141359    .3745633
      lcost2 |   .0658779   .0812145     0.81   0.418     -.094371    .2261268
   lsubsgdp2 |   .2788476   .1453721     1.92   0.057    -.0079944    .5656896
        ledu |   7.455862   2.759546     2.70   0.008     2.010844    12.90088
         not |   .3685013   .4450272     0.83   0.409    -.5096073     1.24661
         acc |   1.284619   .3016158     4.26   0.000      .689484    1.879755
      dyear2 |   .5023714   .2383239     2.11   0.036      .032121    .9726218
      dyear3 |   .9801513   .2497904     3.92   0.000     .4872757    1.473027
      dyear4 |   1.218768   .2680892     4.55   0.000     .6897864    1.747751
      dyear5 |   1.381312   .2856187     4.84   0.000     .8177418    1.944883
      dyear6 |   1.388632   .2942405     4.72   0.000     .8080491    1.969215
        cons |  -11.03708   1.526172    -7.23   0.000    -14.04846   -8.025707
------------------------------------------------------------------------------
```

NON-EU COUNTRIES ONLY

```
      Source |       SS       df       MS              Number of obs =     106
-------------+------------------------------           F( 13,    92) =   66.19
       Model |  518.703162    13  39.9002432           Prob > F      =  0.0000
    Residual |  55.4596037    92   .60282178           R-squared     =  0.9034
-------------+------------------------------           Adj R-squared =  0.8898
       Total |  574.162765   105  5.46821681           Root MSE      =  .77642

------------------------------------------------------------------------------
     lhostsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lgdpc2 |   .9174054    .184775     4.96   0.000     .5504264    1.284384
      lmgdp2 |   .8183255   .2566352     3.19   0.002     .3086259    1.328025
      llines |   .7572534   .2844335     2.66   0.009      .192344    1.322163
    lcelsubs |   .3429042   .0956428     3.59   0.001     .1529494     .532859
      lcost2 |  -.0376906   .0766022    -0.49   0.624    -.1898291    .1144479
   lsubsgdp2 |   .7118833   .1660663     4.29   0.000     .3820614    1.041705
        ledu |  -8.129597   4.286549    -1.90   0.061    -16.64305    .3838594
         not |  -.9233237   .2466681    -3.74   0.000    -1.413228   -.4334196
      dyear2 |   .3720351   .3008806     1.24   0.219    -.2255398      .96961
      dyear3 |   .7957904   .3293804     2.42   0.018     .1416125    1.449968
      dyear4 |   .9640545   .3646505     2.64   0.010     .2398272    1.688282
      dyear5 |   1.035768   .4011962     2.58   0.011     .2389578    1.832578
      dyear6 |   .9763131   .4491356     2.17   0.032      .084291    1.868335
        cons |  -9.501871    1.57542    -6.03   0.000    -12.63079   -6.372952
------------------------------------------------------------------------------
```

MODEL 2 PANEL 1995 – 2000

ALL COUNTRIES

```
      Source |       SS       df       MS              Number of obs =     214
-------------+------------------------------           F( 13,   200) =  117.29
       Model |  1261.31996    13  97.0246124           Prob > F      =  0.0000
    Residual |  165.441381   200  .827206906           R-squared     =  0.8840
-------------+------------------------------           Adj R-squared =  0.8765
       Total |  1426.76134   213  6.69841006           Root MSE      =  .90951

------------------------------------------------------------------------------
     lhostsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lgdpc2 |   1.086875    .139394     7.80   0.000     .8120044    1.361745
      lmgdp2 |   .4833928   .1653758     2.92   0.004      .157289    .8094966
      llines |    .342242   .2331295     1.47   0.144    -.1174652    .8019493
    lcelsubs |   .2501387   .0602597     4.15   0.000     .1313127    .3689646
   lsubsgdp2 |   .1963862   .1377767     1.43   0.156    -.0752952    .4680676
        ledu |   9.345623   2.706262     3.45   0.001     4.009155    14.68209
         not |   .6723262   .4111009     1.64   0.104     -.138322    1.482974
         acc |   1.470981   .2809408     5.24   0.000     .9169951    2.024967
      dyear2 |   .5394321    .224152     2.41   0.017     .0974277    .9814365
      dyear3 |   .9307207   .2400506     3.88   0.000      .457366    1.404076
      dyear4 |   1.189758   .2565334     4.64   0.000     .6839009    1.695615
      dyear5 |   1.318135   .2758105     4.78   0.000      .774265    1.862004
      dyear6 |   1.397557   .2877295     4.86   0.000     .8301841    1.964929
        cons |  -11.78467   1.383696    -8.52   0.000    -14.51318   -9.056168
------------------------------------------------------------------------------
```

NON-EU COUNTRIES ONLY

```
      Source |       SS       df       MS              Number of obs =     124
-------------+------------------------------           F( 12,   111) =   75.21
       Model |  661.184091    12  55.0986743           Prob > F      =  0.0000
    Residual |  81.3187426   111  .732601285           R-squared     =  0.8905
-------------+------------------------------           Adj R-squared =  0.8786
       Total |  742.502834   123   6.0366084           Root MSE      =  .85592

------------------------------------------------------------------------------
     lhostsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lgdpc2 |   1.037201   .1730536     5.99   0.000      .694284    1.380119
      lmgdp2 |   .5842491   .2502084     2.34   0.021     .0884444    1.080054
      llines |   .7471134   .2999656     2.49   0.014     .1527116    1.341515
    lcelsubs |   .2857018   .0877994     3.25   0.002     .1117216    .4596821
   lsubsgdp2 |    .394809   .1635593     2.41   0.017     .0707054    .7189127
        ledu |  -.6596959   4.420676    -0.15   0.882    -9.41956    8.100168
         not |  -.7196817   .2591085    -2.78   0.006    -1.233122   -.2062408
      dyear2 |   .5450244    .290381     1.88   0.063     -.030385    1.120434
      dyear3 |   .8836748    .327479     2.70   0.008     .2347532    1.532596
      dyear4 |   1.155259   .3577229     3.23   0.002     .4464076    1.864111
      dyear5 |   1.200331    .398127     3.01   0.003     .4114162    1.989247
      dyear6 |   1.319377   .4493216     2.94   0.004     .4290159    2.209737
        cons |   -11.2114   1.484567    -7.55   0.000    -14.15316   -8.269628
------------------------------------------------------------------------------
```

.

MODEL 3 PANEL 1998 – 2000

ALL COUNTRIES

```
      Source |       SS       df       MS              Number of obs =     117
-------------+------------------------------           F(  8,   108) =   78.24
       Model |   600.13833     8  75.0172912           Prob > F      =  0.0000
    Residual |  103.554439   108  .958837397           R-squared     =  0.8528
-------------+------------------------------           Adj R-squared =  0.8419
       Total |  703.692769   116  6.06631697           Root MSE      =   .9792

------------------------------------------------------------------------------
     lhostsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lgdpc2 |   .8406026   .2195253     3.83   0.000     .4054653     1.27574
      llines |   .5702465   .3125699     1.82   0.071    -.0493213    1.189814
    lcelsubs |   .1399129   .0807056     1.73   0.086    -.0200596    .2998855
   lsubsgdp2 |    .363904   .1939538     1.88   0.063    -.0205461    .7483542
         not |  -.0002904   .6273715    -0.00   1.000    -1.243849    1.243269
         acc |   .8423383   .4119181     2.04   0.043     .0258452    1.658831
      lmgdp2 |   .6210756   .2400115     2.59   0.011     .1453313     1.09682
        ledu |   8.505815   3.534137     2.41   0.018     1.500543    15.51109
       _cons |  -7.739669    1.79229    -4.32   0.000     -11.2923   -4.187039
------------------------------------------------------------------------------
```

NON EU COUNTRIES

```
      Source |       SS       df       MS              Number of obs =      72
-------------+------------------------------           F(  7,    64) =   70.22
       Model |  302.136694     7  43.1623849           Prob > F      =  0.0000
    Residual |  39.3363571    64   .61463058           R-squared     =  0.8848
-------------+------------------------------           Adj R-squared =  0.8722
       Total |  341.473052    71   4.8094796           Root MSE      =  .78398

------------------------------------------------------------------------------
     lhostsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lgdpc2 |    .646327   .2319906     2.79   0.007     .1828726    1.109781
      llines |   .5692203   .3106604     1.83   0.072    -.0513952    1.189836
    lcelsubs |   .3009205   .0992517     3.03   0.004     .1026425    .4991985
   lsubsgdp2 |   .3864868   .1763116     2.19   0.032     .0342639    .7387097
         not |  -.6934805   .3500861    -1.98   0.052    -1.392858     .005897
      lmgdp2 |   .7690259    .291082     2.64   0.010     .1875227    1.350529
        ledu |   3.473836   4.190952     0.83   0.410    -4.898553    11.84623
       _cons |  -5.995799   1.575067    -3.81   0.000    -9.142357   -2.849242
------------------------------------------------------------------------------
```

MODEL 4 PANEL 1998 – 2000

NON EU COUNTRIES ONLY

```
      Source |       SS       df       MS              Number of obs =      72
-------------+------------------------------           F(  8,    63) =   83.76
       Model |  312.128627     8  39.0160783           Prob > F      =  0.0000
    Residual |  29.3444249    63  .465784523           R-squared     =  0.9141
-------------+------------------------------           Adj R-squared =  0.9032
       Total |  341.473052    71   4.8094796           Root MSE      =  .68248

------------------------------------------------------------------------------
     lhostsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lgdpc2 |   .8127021   .2051253     3.96   0.000     .4027919    1.222612
      llines |    .119927   .2873118     0.42   0.678    -.4542198    .6940737
    lcelsubs |   .1586301   .0917012     1.73   0.089    -.0246201    .3418802
   lsubsgdp2 |    .275684   .1553384     1.77   0.081    -.0347349     .586103
         acc |   .6497942   .3049076     2.13   0.037      .040485    1.259103
      lmgdp2 |   .7721675   .2533975     3.05   0.003     .2657929    1.278542
       dfree |   1.346107   .2906347     4.63   0.000     .7653202    1.926894
         ledu |   12.20053   4.106168     2.97   0.004     3.995009    20.40605
        cons |  -7.135024   1.294234    -5.51   0.000    -9.721344   -4.548704
------------------------------------------------------------------------------
```

MODEL 5 PANEL 1998 – 2000

NON-EU COUNTRIES ONLY

```
      Source |       SS       df       MS              Number of obs =      72
-------------+------------------------------           F(  9,    62) =   58.16
       Model |  305.310654     9   33.923406           Prob > F      =  0.0000
    Residual |  36.1623977    62  .583264478           R-squared     =  0.8941
-------------+------------------------------           Adj R-squared =  0.8787
       Total |  341.473052    71   4.8094796           Root MSE      =  .76372

------------------------------------------------------------------------------
     lhostsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lgdpc2 |   .6825723   .2293027     2.98   0.004     .2242027    1.140942
      llines |    .282041   .3921898     0.72   0.475    -.5019352    1.066017
    lcelsubs |    .307327   .0990958     3.10   0.003     .1092373    .5054167
   lsubsgdp2 |   .3177404   .2041319     1.56   0.125    -.0903134    .7257941
         acc |   .2939153   .3868419     0.76   0.450    -.4793707    1.067201
      lmgdp2 |   .9884274   .3050907     3.24   0.002     .3785598    1.598295
     dindi33 |   .2560443   .4145235     0.62   0.539    -.5725764    1.084665
     dindi34 |   .8647173   .5022019     1.72   0.090    -.1391701    1.868605
        ledu |   5.672082   4.435063     1.28   0.206    -3.193483    14.53765
        cons |  -6.339143   1.477108    -4.29   0.000    -9.291839   -3.386447
------------------------------------------------------------------------------
```

MODEL 6 PANEL 1998 – 2000

NON-EU COUNTRIES

```
      Source |       SS       df       MS              Number of obs =      72
-------------+------------------------------           F( 10,    61) =   71.03
       Model |  314.466937    10  31.4466937           Prob > F      =  0.0000
    Residual |  27.0061145    61  .442723188           R-squared     =  0.9209
-------------+------------------------------           Adj R-squared =  0.9079
       Total |  341.473052    71   4.8094796           Root MSE      =  .66537

------------------------------------------------------------------------------
     lhostsp |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      lgdpc2 |   .8410655   .2027928     4.15   0.000     .4355562    1.246575
      llines |  -.0868349   .3511835    -0.25   0.806    -.7890697       .6154
    lcelsubs |   .1674646   .0916495     1.83   0.073    -.0157999    .3507291
   lsubsgdp2 |   .2319826    .178843     1.30   0.199     -.125636    .5896012
         acc |   .3012972   .3370326     0.89   0.375    -.3726412    .9752357
      lmgdp2 |    .954273   .2659105     3.59   0.001      .422552    1.485994
     dfree   |   1.293406   .2844076     4.55   0.000     .7246974    1.862114
     dindi23 |   .1785282   .3615478     0.49   0.623    -.5444313    .9014877
     dindi34 |   .7083162   .4388835     1.61   0.112    -.1692856    1.585918
        ledu |   13.59775    4.23881     3.21   0.002     5.121728    22.07378
        cons |  -6.844703   1.291695    -5.30   0.000    -9.427606     -4.2618
------------------------------------------------------------------------------
```

ANNEX 3
Data Description, Data Sources and Data Characteristics 2001

Variable name	Description	Number of Obs.	Mean	Std. Dev.	Min	Max
Dependent variables						
hosts	Number of Internet hosts per 100 habitants (Source ITU)	30	3.07	4.39	0.005435	17.09882
Pcp	Personal computers per 100 habitants (Source ITU)	30	20.72	16.80	0.787562	56.224
users	Number of Internetusers per 100 habitants (Source ITRU)	30	19.86	15.10	0.29	51.73
Exogenous variables						
Gni	GNI per capita, Atlas method (current US$) (Source World Bank)	30	13025.33	11468.98	380	41770
Imp	World imports (commercial and merchandise) in US$ as % of GDP (in US$) (Source WTO and IMF)	30	53.13	23.28	24	129
Edu	Education index per 100 habitants (average 1998-1999) (Source UNDP)	30	93.20	4.29	79	99
Lines	Number of main telephone lines per 100 inhabitants (Source ITU)	30	41.87	18.46	4.97	78.3
celsubs	Cellular subscribers per 100 habitants (Source ITU)	30	51.78	30.01	0.656302	97.36546
x1	PSTN monthly subscription (Source ITU)	30	8.26	4.95	0.4	15.9
x4	Dial-Up peak Internet tariffs (US$), (30 hours of use per month) (Source ITU)	30	38.92	16.92	9.66	80.85
Dummy variables						
Dindi1234	1 if telecommunications transition indicator is 1, 2 3 or 4 (omitted category) (Source EBRD)	30	0.13	0.35	0	1
Dindi56	1 if telecommunications transition indicator is 5 or 6 (Source EBRD)	30	0.40	0.50	0	1
Dindi78	1 if telecommunications transition indicator is 7 or 8 (Source EBRD)	30	0.47	0.51	0	1
Eu	1 if EU country (omitted category)	30	0.50	0.51	0	1
Acc	1 if accession country	30	0.27	0.45	0	1
Not	1 if not accession and not EU country	30	0.23	0.43	0	1
Dfree1	1 if country rated free (Source Freedom House) (omitted category)	30	0.83	0.39	0	1
Dfree2	1 if country rated not free (Source Freedom House)	--	--	--	--	--
Dfree3	1 if country rated partially free (Source Freedom House)	30	0.17	0.38	0	1

Annex 4
ESTIMATION RESULTS OF THREE EQUATIONS MODEL 2001

1. General Model Two-stage least square estimation

```
Two-stage least-squares regression
----------------------------------------------------------------------
Equation           Obs  Parms        RMSE    "R-sq"     F-Stat        P
----------------------------------------------------------------------
lhosts              30     12    .7368972    0.9003   13.52934   0.0000
lpcp                30     12    .2713093    0.9706   46.76819   0.0000
lusers              30     11    .3038857    0.9655   45.70535   0.0000
----------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
lhosts       |
      lusers |  -1.132504   3.736229    -0.30   0.763    -8.629795    6.364788
        lgni |  -.6333805   .7652564    -0.83   0.412     -2.16898    .9022188
        limp |  -.5072482   1.309575    -0.39   0.700    -3.135103    2.120607
        ledu |   .2114508   1.977836     0.11   0.915    -3.757367    4.180269
      llines |   1.420672   2.075702     0.68   0.497    -2.744529    5.585874
        lpcp |   1.787313   2.117396     0.84   0.402    -2.461552    6.036178
     dindi56 |  -1.086512   2.223204    -0.49   0.627    -5.547696    3.374673
     dindi78 |  -.1158509   1.411156    -0.08   0.935    -2.947542     2.71584
         lx1 |    .418034   .4505453     0.93   0.358    -.4860512    1.322119
      dfree3 |  -.8710628   2.810198    -0.31   0.758    -6.510138    4.768013
         acc |  -.0323911   .9357165    -0.03   0.973    -1.910044    1.845261
         not |  -.8264722   2.145267    -0.39   0.702    -5.131265     3.47832
       _cons |  (dropped)
-------------+----------------------------------------------------------------
lpcp         |
      lusers |   .0424213   .6084276     0.07   0.945    -1.178478     1.26332
        lgni |    .709535    .236315     3.00   0.004     .2353342    1.183736
        limp |   .3060539   .2158927     1.42   0.162    -.1271664    .7392742
        ledu |   7.209758    4.52475     1.59   0.117    -1.869817    16.28933
    lcelsubs |   .1697384   .1950877     0.87   0.388    -.2217337    .5612105
      lhosts |   .1475431    .392632     0.38   0.709    -.6403305    .9354168
     dindi56 |   .2041493   .1651331     1.24   0.222    -.1272146    .5355131
         lx1 |  -.0580677   .2542387    -0.23   0.820    -.5682349    .4520995
         lx4 |  -.1328201   .1828366    -0.73   0.471    -.4997086    .2340685
      dfree3 |   .1964574   .6597117     0.30   0.767    -1.127351    1.520266
         acc |   .6120552   .3796885     1.61   0.113    -.1498455    1.373956
         not |   .8444942   .4533195     1.86   0.068    -.0651579    1.754146
       _cons |   -38.2536   21.82329    -1.75   0.086    -82.04523    5.538044
-------------+----------------------------------------------------------------
lusers       |
        limp |  -.2050706   .2310501    -0.89   0.379    -.6687065    .2585653
        ledu |   2.315704   4.097179     0.57   0.574    -5.905888     10.5373
      llines |   .5317257   .2976154     1.79   0.080    -.0654833    1.128935
    lcelsubs |   .2094742   .1624111     1.29   0.203    -.1164275    .5353759
        lpcp |   .3273657   .2538173     1.29   0.203    -.1819559    .8366873
     dindi56 |  -.5758394   .3635602    -1.58   0.119    -1.305376    .1536975
     dindi78 |   -.412133   .3617005    -1.14   0.260    -1.137938     .313672
         lx1 |   .2538177   .1541638     1.65   0.106    -.0555346    .5631699
         lx4 |  -.1546552   .1607441    -0.96   0.340    -.4772118    .1679014
         acc |    .163578    .194106     0.84   0.403    -.2259241    .5530801
         not |  -.3885426    .365721    -1.06   0.293    -1.122415    .3453302
       _cons |  -10.14183   18.91703    -0.54   0.594    -48.10164    27.81797
------------------------------------------------------------------------------
Endogenous variables:  lhosts lpcp lusers , Exogenous variables:   lgni limp ledu llines
dindi56 dindi78 lx1 dfree3 acc not lcelsubs lx4
```

2. **Parsimonious Model Two-stage least square estimation**

```
Two-stage least-squares regression
------------------------------------------------------------------------------
Equation           Obs  Parms        RMSE    "R-sq"     F-Stat        P
------------------------------------------------------------------------------
lhosts              30      5    .4988024    0.9355   70.07748   0.0000
lpcp                30      6    .2635677    0.9625   98.39541   0.0000
lusers              30      4    .3229282    0.9459   109.0092   0.0000
------------------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
lhosts       |
        lgni |  -.5245793   .2546272    -2.06   0.043    -1.032169   -.0169893
      llines |   .7969224   .4324537     1.84   0.069    -.0651582    1.659003
        lpcp |   1.147322   .3391174     3.38   0.001     .4713041     1.82334
     dindi56 |  -.5421354   .1919633    -2.82   0.006    -.9248071   -.1594636
         lx1 |   .5368831   .2122602     2.53   0.014     .1137502     .960016
       _cons |  -1.746196   2.136312    -0.82   0.416    -6.004856    2.512464
-------------+----------------------------------------------------------------
lpcp         |
        lgni |   .8138517   .1349726     6.03   0.000     .5447887    1.082915
        limp |   .2535341   .1273351     1.99   0.050    -.0003038     .507372
        ledu |   8.675353   1.554028     5.58   0.000     5.577455    11.77325
    lcelsubs |   .1953388   .1106098     1.77   0.082    -.0251578    .4158354
         acc |   .8048157   .2160354     3.73   0.000     .3741571    1.235474
         not |   1.068005   .2881751     3.71   0.000     .4935384    1.642472
       _cons |  -46.14968   6.898844    -6.69   0.000    -59.90228   -32.39709
-------------+----------------------------------------------------------------
lusers       |
      llines |    .749391      .2644     2.83   0.006     .2223191    1.276463
        lpcp |   .4941044   .1315671     3.76   0.000     .2318302    .7563786
     dindi56 |  -.2860577   .1240904    -2.31   0.024    -.5334273   -.0386881
         not |  -.6452853   .2006128    -3.22   0.002      -1.0452    -.245371
       _cons |  -1.206624   .7282883    -1.66   0.102     -2.65844    .2451926
------------------------------------------------------------------------------
Endogenous variables:  lhosts lpcp lusers
Exogenous variables:   lgni llines dindi56 lx1 limp ledu lcelsubs acc not
```

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