Patrice Muller and Pau Salsas1
London Economics

Internet Use in Transition Countries – Economic and Institutional Determinants

1 The views and opinions expressed in this paper are those of the authors only.

Contact details: Patrice Muller or Pau Salsas, London Economics, 60, Lombard Street, London, EC3V 9EA, United Kingdom. Telephone: +44 207 464 8637/8647, e-mail:pmuller@londecon.co.uk or psalsas@londecon.co.uk

INTERNET USE IN WESTERN, CENTRAL AND EASTERN EUROPE
ECONOMIC AND INSTITUTIONAL DETERMINANTS2

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 productivity3 and to a much lesser extent on the specific economic impact of Internet4.

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 Africa5 (Conte, 2000), the third one on Latin

2 This is a revised and expanded version of a paper presented at the WIDER conference on "The New Economy in Development" held in Helsinki May 10-11, 2002 and presented at the XXVII Simposio de Analisis Economico. Salamanca, Spain. 12-14 December, 2002.

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, 20015, Wallsten, 2002) and one on Internet use by businesses in Central and Eastern Europe (Clarke, 2002).

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.

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.

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 usage8 and we will use the number of Internet hosts, as published by the ITU9. 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.S10 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.).

4 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**	**EUAccession 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	6.5	5.9	9.7	*1.6*	19.5	*3.3*

hosts						

Source: ITU (2002)

(1) = standard deviation divided by average

(2) = including Bulgaria and Romania

(3) = excluding Bulgaria and Romania

5 Figure 1Number of Internet hosts and users in the European Union and Central and Eastern Europe (per 10,000 inhabitants) 0100020003000400050006000050010001500200025003000350040000Internet hostsInternet usersUSA Finland Netherlands Denmark Sweden Correlation coefficient = 0.73

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 interest11. As the Internet is still a relatively young phenomenon and started to take off only around 199312, 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 â convergence and ó 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 countries13.

In contrast, â 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) ăi, $_{1995,2001}$ = á – â * log(yi, $_{1995}$) + Íi, $_{2001}$ where

(2) ăi, $_{1995,2001}$ is equal to log(yi, $_{2001}$/ yi, $_{1995}$)($^{1/6}$)

The detailed estimated ó convergence and â convergence statistics14 are reported in Tables 2 and 3. First, the results of the ó 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 (ó of 0.99 versus ó of 1.41); and,

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

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 â 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

ó **Convergence1: 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) ó **convergence = normalised standard deviation of log of yi, where y = number of Internet hosts per capita and i = country i**

Source: ITU (2001)

Table 3

Absolute â Convergence – Number of Internet Hosts Per Capita

1995-2001

ăi, 1995,2001 = á – â * log(yi, 1995) + Íi, 2001

(t- statistic in parenthesis)

	All countries	**EU**	**Non-EU**
á	0.323 (9.93)	0.313 (13.99)	0.340 (4.37)
â	-0.041 (5.44)	-0.047 (2.84)	-0.039 (2.72)
Adj. R2	0.45	0.38	0.28
RMSE	0.13	0.07	0.16

ăi, 1995,2001 = log (yi, 2001/ yi, 1995)$^{(1/6)}$ and yi = 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)1617.

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

(2) $Yt_{,i} = á + ‡”â1j\ X1j_{,t,i} + ‡”â2j\ X2j_{,t,i} + ‡”â3j\ X3j_{,t,i} + ä1\ acc + ä2\ not + Ít_{,i}$

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,

- $Yt,_I$ = 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 form18 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 results20 for models 1 to 6 are provided in Annex 1 and, to facilitate their analysis, are summarized in Table 521.

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. R2	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 R2 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 (2) to (4):

(2) $Y1t_{,i}$ = á1+‡”â11j $X1j_{,t,i}$ + ‡”â12j $X2j_{,t,i}$ + ‡”â13j $X3j_{,t,i}$ + ‡”â14j $X4j_{,t,i}$+ä11 acc + ä12 not + ä13 dfree3 + ä14 dindi56+ ä15 dindi78+ ô11 * Y2t,i + ô12 * Y3t,i + Í1t,i

(3) $Y2t_{,i}$ = á2+‡”â21j $X1j_{,t,i}$ + ‡”â22j $X2j_{,t,i}$ + ‡”â23j $X3j_{,t,i}$ + ‡”â24j $X4j_{,t,i}$+ä21 acc + ä22 not + ä23 dfree3 + ä24 dindi56+ ä25 dindi78+ ô21 * Y1t,i + ô22 * Y3t,i + Í2t,i

(4) $Y3t_{,i}$ = á3+‡”â31j $X1j_{,t,i}$ + ‡”â32j $X2j_{,t,i}$ + ‡”â33j $X3j_{,t,i}$ + ‡”â34j $X4j_{,t,i}$+ä31 acc + ä32 not + ä33 dfree3 + ä34 dindi56+ ä35 dindi78+ ô31 * Y1t,i + ô32 * Y3t,i + Í3t,i

Where: $Y1t_{,i}$ = number of personal computers per capita, $Y2t_{,i}$ = number of Internet hosts per hundred of inhabitants and Y3t, = 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 variables1	**Hosts**	**PCs**	**Users**	**Hosts**	**PCs**	**Users**
Explanatory variables1						
hosts	--	+	--	--		
Pcs	+	--	+	+***		+***
users	-	+	--	--		
GNI	--	+*** --		-***	+***	
imp	-	+ -		--	+***	
edu	+	+	+	--	+***	
lines	+	--	+**	+***	+**	+***
celsubs	--	+	+	--		
dindi56	-	+	-**	-***		-***
dindi78	-	-- -		--		
x1	+	-	+*	+***		
x2	--	-	-	--		
dfree2	--	--	--	--		
dfree3	-	+	--	--		
acc	-	+* +		--	+***	
not	-	+ -		--	+*** -***	
Constant	--	-	-	-	-	-
"R2"	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 hosts23 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.

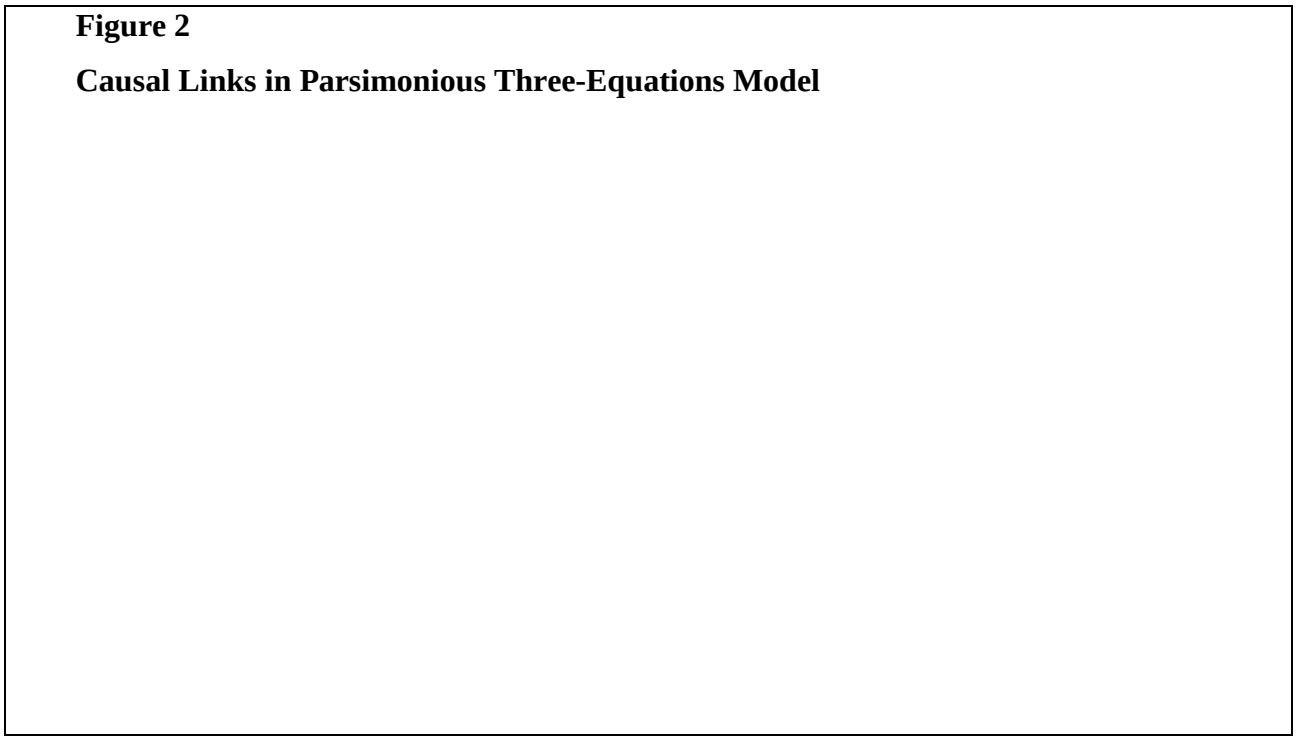
In essence, the estimation results suggest that socio-economic variables affect mainly the number of personal computers in a country. And, the latter variable together with the number of telephone lines and the state of liberalisation of the telecommunications sector determines the number of Internet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

.

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.

Number of Personal Computers

Socio-Economic Variables:

GNI, Education, Trade Openness, Number of Cellular Phone Subscribers

Number of Internet Hosts

Number of Internet Users

Number of telephone lines, state of telecommunications liberalisation

EU accession country,

Non-EU accession transition economy

Cost of Monthly Telephone subscription

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 Sector1**
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.

VII. Concluding Remarks

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	EBRD see Box below

	otherwise	
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

<u>MODEL 4 PANEL 1998 – 2000</u>

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	30	20.72	16.80 0.787562 56.224		

	(Source ITU)					
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 telecommunicati	30	0.40	0.50	0	1

	ons transition indicator is 5 or 6 (Source EBRD)					
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
```

Bibliography:

1. Brynjolfson, Erik and Lorin M. Hitt, Beyond Computation: Information Technology, Organizational transformation and Business Performance, Journal of Economic Perspectives, Vol. 14, No. 4, Fall 2000, pp. 23-48
2. Clarke George R.G., Does Internet Connectivity Affect Export Performance? Evidence from Transition Economies, WIDER Discussion Paper 2002/74, August 2002
3. Cohen, Stephen S., J. Bradford deLong and John Zysman, Tools for Thought: What is New and Important About the "E-conomy"?, BRIE Working Paper No. 138, Berkeley, February 2000 (downloaded from http://brie.berkely.edu/~briewww/pubs/wp/index.html on 5/5/2001)
4. Conte Bernard, Les déterminants de la diffusion d'Internet en Afrique, Document de travail 48, Centre d'Economie de Développement de l'Université Montesquieu Bordeaux IV, 2000

5. Dasgupta Susmita, Somik Hall and David wheeler, Policy Reform, Economic Growth and the Digital Divide, mimeo, World Bank, 2000
6. EBRD Transition Report 2001, London, November 2001
7. European Commission (a), eEurope2002, An Information Society For All, Action Plan, prepared by the Council and the European Commission for the Feira European Council, 19-20 June, Brussels, June 2000
8. European Commission (b), The eEurope Update, Prepared by the European Commission for the European Council in Nice 7th and 8th December 2000, Brussels, November 2000
9. European Commission (c), eEurope 2002, Impact and Priorities, A communication to the Spring European Council, Stockholm 23-24 March 2001, Brussels, March 2001
10. European Commission (c), eEurope+2003, A co-operative effort to implement the Information Society in Europe, Action Plan prepared by the Candidate Countries with the assistance of the European Commission, June 2001
11. Freedom House, FH Country Ratings, downloaded from www.freedomhouse.org/ratings/index.htm on 15/3/2002
12. G7/G8, Impact of the IT revolution on the Economy and Finance, Report from the G7 Finance Ministers to the Heads of State and Government, Fukuoka, Japan, July 8, 2000 (downloaded from www.g7.utoronto.ca on 15/04/2001)
13. Gordon, Robert J., Does the "New Economy" measure up to the Great Inventions of the Past, Journal of Economic Perspectives, Vol. 14 No. 4, Fall 2000, pp. 49-74
14. Hargittai Eszter, Weaving the Western Web: explaining differences in Internet connectivity among OECD countries, Telecommunications Policy, Vol. 23, pp. 701-718, 1999
15. ITU, Yearbook of Statistics Telecommunication Services 1991 –2000, Geneva, 2001
16. ITU, World Telecommunication Development Report – Reinventing Telecoms World Telecommunications Indicators, Geneva 2002
17. Jorgensen, Dale W., Information Technology and the U.S. Economy, The American Economic Review, Vol. 91 No. 1, March 2001, pp. 1-32
18. Kraemer, Kenneth and Derdick, Jason, The Productivity Paradox: Is it Resolved? Is There a New One? What Does it All Mean for Managers?, Center for Research on Information Technology and Organizations, University of California, Irvine, February 2001
19. Litan E. Robert and Alice D. Rivlin, Projecting the Economic Impact of the Internet,

American Economic Review, Papers and Proceedings, Vol. 91, No. 2, May 2001, pp. 313-317

20. Minges Micheal, Counting the Net: Internet Access Indicators, 2000
21. Muller, Patrice, Internet Use in Transition Economies: Economic and Institutional Determinants. WIDER Discussion Paper 2002/95, October 2002
22. Nordhaus, William D., Productivity Growth and the New Economy, NBER Working Paper 8096, January 2001
23. OECD(c), Understanding the Digital Divide, Paris, 2001
24. Oliner, Stephen D. and Daniel E. Sichel, The Resurgence of Growth in the Late 1990s: Is Information Technology the Story? Journal of Economic Perspectives, Vol. 14 No. 4, Fall 2000, pp. 3-22
25. Onyeiwu, Steve, Inter-Country Variations in Digital Technology in Africa: Evidence, Determinants and Policy Applications, WIDER Discussion Paper, 2002/72, July 2002
26. Piatkowski, Marcin, The 'New Economy' and Economic Growth in Transition Economies, WIDER Discussion Paper 2002/62, July 2002
27. Pohjola, Matti, Information Technology and Economic Development, An Introduction to the Research Issues, WIDER Working Paper No. 153, November 1998
28. Spiller Pablo T. and Carlo G. Cardilli, The Frontier of Telecommunications Deregulation: Small Countries Leading the Pack, Journal of Economic Perspectives, Vol.11, No. 4, September, 1997, pp.127-138
29. Stiroh, Kevin J., Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say? , American Economic Review 92, No. 5, December 2002
30. UCLA Center for Communication Policy, Surveying the Digital Future, The UCLA Internet Report, November 2000 (downloaded from www.ccp.ucla.edu on 16/04/2001)
31. Wallsten, Scott J., An Econometric Analysis of Telecom Competition, Privatization, and Regulation in Africa and Latin America, The Journal of Industrial Organization, Vol. XLIX, No. 1, March 2001
32. Wallsten, Scott, J., Regulation and Internet Use in Developing Countries, World Bank Working Paper No. 2979, December 2002
33. Werle Raymund, Internet@Europe: Overcoming institutional fragmentation and policy failure, European Integration online Papers, Vol. 5, No. 7, 2001, downloaded from http://eiop.or.at on 11.10.2001