DIGITAL DIVIDE AND CROSS COUNTRY DIFFUSION OF THE INTERNET

by

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Abstract

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This paper explores the issue of "digital divide" – the gap between countries that have highly developed technologies, measured by the Internet adoption, and those which do not – by utilizing a classical approach towards convergence estimation across countries. The estimated results suggest that there exists both an absolute and conditional convergence, implying that the "digital divide" bridges over time so that inequality between countries in terms of the Internet development vanishes over time, or that the extent of inequality does not become larger. The main factors stipulating the diffusion process of the Internet which reduces the "digital divide" are determined. The results show such indicators as GDP per capita, costs of connection, and infrastructure development to be of paramount importance for the adoption of the Internet. Finally, the findings are subject to a sensitivity check, which shows the main results to be quite robust.

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GLOSSARY

The Internet is a worldwide system of computer networks – a network of networks in which users at any one computer, they have permission, get information from any other computer (and sometimes talk directly to users at other computers).

Host is any computer that has two-way access to other computers on the Internet and provides Web documents to clients or users.

Server is a computer running software, assigned IP address, and connected to the Internet so that it can provide documents via the World Wide Web.

Internet user is a person who uses Internet services.

IP address is an identifier for a computer or device on a TCP/IP (Transmission Control Protocol/Internet Protocol) network, the suite of communications protocols used to connect hosts on the Internet.

World Wide Web is a system of Internet servers that support specially formatted documents. The documents are formatted in a markup language called HTML (*HyperText Markup Language*) that supports links to other documents, as well as graphics, audio, and video files, and allows jumpinig from one document to another simply by clicking on hot spots. Not all Internet servers are part of the World Wide Web.

Digital divide is the gap between those who can effectively use new information and communication tools, such as the Internet, and those who cannot.

CHAPTER1.

Introduction

Over the last 10-15 years there has been a very optimistic belief among people regarding the development of Information and Communication Technologies, in particular the Internet. This is not surprising, since starting from 1981 the magnitude of Internet diffusion measured in terms of the number of Internet hosts soared from 213 to 171,638,297 by 2003 (Internet Software Consortium, 2003).According to the International Telecommunication Union the number of Internet users was 4 mln. in 1991 and increased to 580 mln. by the end of 2002. There is a strong belief that “ICT is spreading faster than any other technology in the whole of human history” (The Economist, 2001, p.10). Analysts claim that in this information era countries have already turned into “knowledge economies” and “network societies” (Selwyn, 2003). Being a part of this network is crucial and essential for all aspects of life since it changes the way people learn, communicate, do business and participate in civil life. Different benefits, such as improved services’ delivery, distance education, etc. can be reaped with the help of the Internet. Besides, it provides excellent possibilities to increase productivity, efficiency, and competitiveness both for individuals and countries. A survey by PricewaterhouseCooper in March 2001 concluded that U.S. firms with Internet based business solutions have annual productivity gains of more than 13 per cent compared to less than 5 per cent of those that do not use the Internet. At the same time, easy access to information and its exchange leads to the minimization of the transaction costs (Joseph, 2002). Indeed, Varian and Litan conducted a study which shows that Internet business solutions yielded a cumulative costs savings of $155.2 bl. to U.S. firms and they predict it to increase to more than $500 bl. by 2010.

In a modern society, with its tendency for globalization, the Internet plays an important role. It has transformed the way people make money by creating the so called "new economy". It offers efficient and relatively cheap service, thus broaden access to information and communication for individuals and businesses around the world. By the means of the Internet any business in the Ukraine can make a deal with an Australian business, and a teacher in Nigeria can have an access to the same data as someone in New York City. In all these cases the Internet is expected to level the playing field and to reduce the traditional disadvantages of the developing world (Norris, 2000). This is in some sense too rosy picture which is not always the case in reality.

The Internet indeed provides enormous benefits in terms of information and contacts leading to cost reduction. But, at the same time, it increases global inequality in the world since countries have different initial conditions for the Internet to take off (United Nations Report, 1999). It seems to be logical to assume that more prosperous countries can benefit from the Internet to higher extent. Gains in productivity brought by the use of the Internet make the inequality across countries even sharper and raise the concern about "digital divides" between them. For instance, Iceland has 2,370.17 Internet hosts per 10,000 inhabitants while Belarus has only 4.06. What is more interesting is that even among transition countries the rate of diffusion of the Internet varies greatly. The first in this group is Estonia with 467.63 Internet hosts per 10,000 inhabitants and the last one is Albania counting only for 0.43 Internet hosts per 10,000 inhabitants (ITU, 2002).Thus, developing and transition countries are left behind the developed one in terms of the accelerated productivity and growth provided by the Internet.

This paper attempts to ascertain the main factors determining the diffusion of the Internet across countries and empirically estimate such notions as "bridging the digital divide" employing both the absolute and conditional convergence concept for this purpose. To provide high level of diffusion it is necessary to know what factors influence this process and how it progresses. The pattern of the Internet diffusion is expected to depend mainly on the nation's development level characterized by economic, political and cultural aspects. Uneven spread of the Internet around the world, caused by fundamental differences in the economic and political system within certain groups of countries, may be reduced by exploiting direct investments (Clarke, 2001) or other means of stimulating the development of informational infrastructure.

It is important to know the main determinants of Internet diffusion for enterprises and policy makers who might be interested in such information to plan their on-line activities and decide upon investment attractiveness of a country, education, deregulation of telecommunication industry, Internet infrastructure planning, etc. It is also important to know these factors to decide whether government should intervene in the diffusion process of the Internet and, if it should, to what extent. For instance, the Ukrainian Ministry has announced that in 2005 it will provide legal services to individuals through the Internet. (The Korrespondent, April, 4, 2004) Besides, starting from March, 2004 Ukrainian individuals will be allowed to fill in a tax return on-line. One more example which also provides evidence how prudent government intervention into the telecommunication industry might promote the development of the Internet is the fact that in 2002 the U.S. Congress approved a law according to which Internet Service Providers of high speed connectivity were temporally exempted from the tax payments. In April 2004 U.S. President Bush proposed to make this exemption permanent in order to deepen the diffusion of particularly this type of Internet adoption.

The issue of bridging the digital divide is of paramount importance as well. The existence of convergence (whether absolute or conditional) in the diffusion of the Internet means that the gap between countries that have widely spread access to the net (so called “haves”) and those that do not (so called “have nots”) becomes smaller and might even disappear over time, thus reducing inequality around the world. To be able to bridge the “digital divide” it is important for policy makers to know what factors explain differences across countries. Since countries in the sample differ a lot in terms of political, cultural, economical, etc. aspects, which mean they already have different steady states, it is worth considering both absolute and conditional convergence.

The paper has the following structure: the first chapter outlines the main literature on diffusion and the digital divide in general, and studies conducted on the spread of the Internet across countries. The second chapter describes the models under study and some hypothesis. The third chapter explains the peculiarities and drawbacks of data and how the variables that enter the regressions were constructed. The fourth chapter contains empirical results, including robustness check, and provides conclusions based on conducted analysis. The paper concludes with policy implications.

CHAPTER2.

Literature Review.

In spite of the fact that the Internet diffusion issue has been discussed quite a lot there is only a limited number of academic studies investigating the main determinants of this process. The explanations underlying this problem are rooted in the fact that it is difficult to pin down the essence of the spread of the Internet across countries using available data on the number of hosts and Internet users. A deep understanding of the diffusion process involves economic, political, and cultural aspects which are either difficult to present in numerical equivalent or do not exist in a form suitable for empirical estimation. The same problems cause the fact that the issue of bridging the digital divide has not yet been estimated, while non-the-less being discussed at length. Given all the complications with respect to data at disposal there are a few studies that attempt to determine the general factors explaining the Internet adoption in a country. All the studies can be grouped with accordance to whether the authors utilized an empirical or a descriptive approach. The later case appears when authors assess the level of Internet adoption by considering given figures and trying to suppose what might cause them to be as they are. This group of studies involves several case studies that describe the influence of a particular factor on the diffusion of the Internet. For instance, Vehovar at al. (1999) consider not having English language as a native being a barrier for the Internet penetration with Slovenia as an example. They find that individuals want more web pages to be provided in their primary language. Some scholars (Huang at al. (2003), Volken (2002)) argue that Internet penetration significantly depends on the level of trust in a country, particularly in highly fragile Eastern European transformational societies. The authors argue that differences in trust might, in fact, promote an increasing digital divide between countries. Wolcott at al. (2001) propose a descriptive framework to analyze the diffusion process and call it "Global Diffusion of the Internet methodology" (GDI). The authors argue that the Internet should be perceived as a cluster of interrelated constituent technologies, and its adoption cannot be considered completed at the point in time when an individual decides to use it. The real spread of the Internet is supposed to be affected by such factors as the computer skills of individuals. They propose to construct country-level diffusion metrics with six dimensions that capture the important feature of Internet adoption in a country. The dimensions they consider are *Connectivity Infrastructure* (assessment of network infrastructure), *Organizational Infrastructure* (description of the number of Internet Service Providers and competitiveness in the industry), *Sophistication of Use* (for what purposes the Internet is Used) , *Pervasiveness* (function of the number of users per capita), *Geographic Dispersion* (physical spread of the Internet within a country), *Sectoral Absorption* (to what extent main sectors of economy explore the Internet). As the authors believe, each factor graphed on the Kiviat diagram[1] demonstrates its significance to the diffusion process. Each of the dimensions includes sub factors that describe it to full extent (e.g. different levels of sophistication of use, the organizational and connectivity infrastructure, major Internet-use sectors of economy, etc). However, it is quite obvious that this methodology is rather time and effort consuming since in order to obtain the true picture of global diffusion of the Internet it is necessary to construct the diagrams for all countries around the world and this might be complicated in an ever changing economic and political environment.

The experiment undertaken in small town LaGrange, Georgia, U.S. in April 2000 can be attributed to this group of descriptive studies. The main purpose of this case study was to assess whether it is possible to address the digital divide

[1] Will be presented in the appendix of the final version of the paper.

by providing broadband Internet access to every citizen and to what extent. The initiators of such type of this experiment strongly believed that this way of asserting the digital divide issues was one of the best to answer the questions "why" and "how". Besides, it provided the possibility to study this problem in "natural setting". As Keil at.al. (2002) claims "in spite of some positive results, the Free Internet Initiative has failed to have the impact that policy makers had hoped for with respect to bridging the digital divide". According to the authors the main reasons of such a failure are hesitancy, a lack of appreciation, and a lack of understanding. Certain groups of individuals did not embrace this initiative due to the fact that they could not afford to have a computer to enjoy free access to the Internet, others did not want to change the way they were connected to the Internet. As a result, the penetration rate of the free service was about 45% by November 2001. This real case suggests the issue of bridging the digital divide being complicated to measure and, in particular, to implement.

Another group of studies utilizes the most common indicators of the level of the diffusion of the Internet in a country – number of users and number of hosts. In doing so researchers try to find the most statistically significant factors that are to explain peculiarities of the diffusion process in a particular country. All the studies are based on the theory on diffusion of innovations and utilize its basic ideas. Thus, for instance, the main assumption underlying the theory of diffusion is that the process of adoption of innovations follows an S-shaped curve (Rogers, 1995). Indeed, at the very beginning of the introduction of a new product the number of actual users is quite small. As time passes and more individuals become aware with the product a number of users rises so that saturation point[2] is achieved. At the end of the process the increase in the number of users slows down. The extreme assumption regarding the ultimate number of users is that it equals the population of a country. Rogers (1995)

[2] Point at which all potential users become actual users.

claims that the diffusion of an innovation consists of five stages: knowledge - individuals become aware of an innovation and have some idea how it functions, persuasion – individuals form their own attitude towards an innovation, decision – individuals decide whether to adopt or not to adopt an innovation, implementation – individuals start using an innovation, and confirmation – individuals evaluate the results of their decision to adopt an innovation. People base their decision to adopt an innovation on a cost-benefit analysis with the main goal to increase their utility. According to Roger all individuals can be divided into five groups with respect to their response to new products: innovators (2,5%), early adopters (up to 13,5%), early majority (34%), late majority (34%), and laggards (16%).

Geroski (2000) suggests exploring several models to investigate technology diffusion, namely epidemic model, probit model, models based on legitimating and competition, and information cascades. The epidemic model is based on the assumption that diffusion does not happen rapidly due to the lack of available information for potential users. Information diffusion process does not flow smoothly thus creating asymmetric S-curve. This can be explained by the fact that information diffusion process itself is affected by a "word of mouth" process. The authors distinguish several versions of the epidemic model with accordance to initial source of information, namely central source mode and mixed information source model. The probit model presumes that individuals/firms have different goals and abilities and, as a result, are more likely to adopt the technology at different point in time. The main issue in the probit model is to identify relevant characteristics of individuals/firms. As it is stated by the author the most common variable explored in the empirical studies on diffusion is firm size. It is quite logical, since this factor can be utilized as a proxy for wide variety of firms' characteristics. In addition the probit model includes such factors such as technological expectations, learning, search costs, switching costs, and opportunity costs. In the models based on legitimation and competition these twin forces "help to establish new technologies and then ultimately limit their take up". Information cascades models explore the fact that initial choice between different variants of new technology affects the speed of subsequent diffusion. The author claims that the presence of network externalities may strengthen this process. Furthermore, the process of the diffusion driven by information cascades consists of three stages: the initial choice, the lock-in, and the bandwagon.

Within the group of empirical studies one can distinguish between macro and micro approaches towards determination of the main factors. The former is based on macro indicators regarding the Internet and the later explores survey data for enterprises and individuals.

Vagliasindi and Vagliasindi (2003) investigate the main determinants of the Internet adoption at the enterprise-level and then add country-level variables ("GDP per capita", "fixed line penetration", "democracy", and "corporate governance") for the case of transition countries. In fact, the main focus of the study is to consider "microeconomic evidence" on the rate of diffusion of the Internet from the major enterprise level survey carried out by the EBRD and the World Bank in 1999. Adding country-level variables to check for macro evidence the authors corroborate Canning's (1999) finding about the importance of the level of basic telecommunication infrastructure and find that countries with higher income per capita and those with democratic political regime are more likely to have a higher level of the Internet diffusion. Controlling for the level of political freedom in a country seems to be quite reasonable since there exist several instances, in particular within CIS countries, when authorities practice heavy intervention into the telecommunication industry in order to prevent the spread of undesirable information. However, the authors argue that some level of regulation leading to better infrastructure and greater competition bring benefits in terms of better quality of services and lower prices among Internet Services Providers (ISP).

To determine the main factors of Internet diffusion at a micro level and to analyze what type of enterprises have higher probability to adopt the Internet, the authors utilize the two outcomes probit model[3] that reflects individuals'/enterprises' decision whether to adopt or not to adopt the Internet based on different goals and abilities. Thus, they assume that more innovative firms are more likely to adopt such a new technology as the Internet is. Firms that experience foreign and domestic competitive pressure try to exploit the most cost saving tools. Controlling for the firm's size, geographical location, export/import orientation, rate of growth of sales, ownership, hardening of budget constraints, and network externalities effect the main findings are: outward oriented firms exploring cost-reducing innovations and allowing for foreign competitive pressure are more likely to adopt the Internet. Network effects (measured as a population density dummies) are also highly significant, that is, the value of the Internet increases with the number of actual users. This result contradicts Canning's (1999) argument that the size of the network is not important. The reason for this conflict might account for the differences in samples utilized in both studies.

Clarke (2001) analyzes micro-level data for over 3000 enterprises from 21 transition countries to determine the factors that influence whether enterprises in a country have Internet access. Using the standard maximum likelihood approach the author estimates a model which includes enterprises characteristics (how it was established, ownership, size, sector of operation, competition, and performance) and country characteristics (income per capita, population, urban population, telephone infrastructure, openness to trade and

[3] Probit model is introduced in details in the second chapter.

investment). Estimation suggests that foreign ownership has a strong and positive effect on the probability for enterprises to have access to the Internet. Companies that consider their main competitors to be foreign enterprises, either producing domestically or importing, are more likely to use the Internet. Furthermore, the results prove that openness to trade and investment increase the likelihood that enterprises are connected to the Internet, though openness to trade appears to be less significant. Regarding the enterprises' origin, the study shows that those established as *de novo* private or joint ventures have higher probability to adopt the Internet. Including the indicators of enterprises' performance – sales growth, employment, etc. – the author finds better performing companies to have higher probability of Internet connection. This result is quite expected since well performing enterprises have more resources available to invest in new technologies such as the Internet. At the same time, as it is stated by the author, causality between the existence of the Internet in enterprisers and their performance might work the opposite way. Controlling for the country level indicators the study provides a quite unexpected finding that foreign direct investment does not have a significant effect on the probability for enterprises to adopt the Internet. In general, the results on income per capita, population and the development of the telecommunication system coincide with other studies and show that a developed infrastructure positively affect the probability for Internet adoption, the higher per capita income the higher is the likelihood of Internet use, small countries with large urban population are more likely to be connected to the Internet.

One of the factors that is assumed to be a main determinant of the adoption of the Internet in a country (and enters all the regressions we are familiar with) is the level of development of infrastructure. Canning (1999) focuses on the effect of quality, quantity and pricing of telecommunication infrastructure as explanatory factors of the level of the Internet penetration. Undertaking a cross-countries study he finds that the major determinant of the Internet adoption is the quality of telephone lines in a country while the size of the network (quantity) and the manner of pricing utilized did not appear to be statistically significant. Besides, as it is marked by the author himself, one of the problems with the study is the fact that countries with no Internet use are ignored in the estimation. As a result, this leads to the selectivity bias in the estimates since the omission of the countries is not random. Furthermore, the author argues that the telephone system is the main channel for Internet access which, indeed, was the case at the time the study was conducted. Recent surveys (e.g. Jupiter, 2002, Forrester, 2002) show that broadband connection is replacing the old means of connection to the Internet. This, in turn, might change the conclusions about the quantity and pricing drawn by Canning (1999).

One more study based on the number of Internet hosts and attempting to assess the diffusion of the Internet across countries is one by Kiirski and Pohjola (2001). The authors estimate the Gompertz model of technology diffusion for OECD countries and then extend it for the rest of the world, but only with countries that have a population of more than one million and where the number of Internet hosts was larger than 50 in 1995. As it is stated by the authors the latter condition was imposed to avoid modeling the initial adoption of the Internet in a country. Analyzing the diffusion of the Internet in OECD countries the authors make a critical assumption that the diffusion process is the same in all countries. It means that parameter values of the equation have the same value for all countries. However, in a light of concerns of the digital divide across countries this assumption might not hold in case of developing and transition countries and the authors do not specify what countries they extend the sample with. Following the theory on diffusion they make one more assumption that the initial number of technology users H_{it} tends to the saturation point H_i*[4].

The authors control for different factors such as competition in telecom industry, average years of schooling in a country, English proficiency, Nordic country (Denmark, Finland, Norway and Sweden) and "Southern" country (France, Greece, Italy, Mexico, Portugal, Spain and Turkey) and run separate regressions. Splitting the initial regression into two parts while controlling for differences between northern and southern countries the authors still assume that the diffusion process is the same but within a particular group. The factors included into the model are foreordained by simple logic and reality. Thus, it is widely known that human capital, here measured in terms of years of schooling, is crucial for the adoption of new technologies. English proficiency enters the regression due to the fact that 87 per cent of all web pages available on the Internet are in English (Inktomi Corp., 2000). Division of countries into "Nordic" and "Southern" capture the fact that Scandinavian countries are rated at the top of the list of most advanced countries with respect to the number of Internet users per 10,000 inhabitants (ITU, 2002).

In contrast with the study of cross country diffusion by Hargittai (1999) the results show that there exists a negative impact of access costs on Internet connectivity while such factor as a monopoly in telecommunication per se is not statistically significant for the prediction of computer hosts per capita. Furthermore, years of education has appeared to be statistically insignificant among the OECD countries. Surprisingly, English proficiency has a negative sign in the regression. However, the general conclusion that education has no predictive power coincides with Hargittai (1999). In general, the authors claim that GDP per capita and Internet access costs explain best the growth in

[4] The Gompertz is explained in details in the third chapter.

adoption of the Internet measured in terms of the numbers of Internet hosts in a country.

Both cross-section and panel estimation are explored to analyze the extended sample. A simultaneous equations system is utilized and estimated with three-stage least squares. In this specification “years of schooling” becomes statistically significant in comparison with previous analysis. The authors emphasize that it should not be so unexpected since an increase in the number of observations leads to more variability of the schooling variable.

Milner (2003) considers five explanatory factors that might influence the global diffusion of the Internet across countries. Trying to pin down why countries adopt the Internet at different paces she argues that they experience some degree of pressure which can take five different forms. First, powerful counties could influence the policies and choices of lesser developed countries. This argument seems to be quite logical and, for instance, Hargittai (1998) claims that U.S. cultural aspects and norm prevail on the network since it is the country with the most developed Internet infrastructure. As a result, a large part of the content on the Internet presents U.S. points of view. U.S. dominance is measured by constructing special variable as U.S. users/hosts per capita relative to total number of users/hosts. This measure declines over time as more countries adopt the Internet. A second reason for the diffusion could be competitive pressures countries experience on the global market. Seeking for an efficient way to operate countries choose cost saving technologies and reap the advantages the Internet brings. To check for the economic competition the author considers the development of the Internet of a country’s top ten trade partners, the average number of user/hosts per capita in a country’s geographic region, and average number of users/hosts per capita for a country’s neighbors. A third reason accounts for the process of rational learning which stands for the situation when countries watch what policies are implemented by others and try to copy those proved to be beneficial. In addition to the variable on region and neighbors a variable reflecting the membership in WTO is estimated. Indeed, being a member of any international organization enforces a country to learn from others. A fourth form of pressure affecting the global spread of the Internet is the network externalities. Assuming that the Internet technology provides increasing returns to scale and scope it is argued that the value for any individual/country to be a part of the network increases with the number of its participants. The network effect is measured by the variable calculated as total number of users/hosts in the world in year t minus the number of users/hosts in a country itself in year t. A fifth form for a country to experience pressure towards the diffusion of the Internet is to be involved into the social emulation process. This is particularly urgent for countries with common history, close linguistic and cultural ties since imitation of "similar" countries makes authorities to adopt innovations faster. The author estimates this pressure utilizing common colony heritage of countries, religion traits and country's native language. Given the data at disposal we will test these hypotheses separately for transition, developing and developed countries and compare the results. Common heritage for transition countries could be joined Soviet past and, especially, being a part of the USSR.

Following the idea of S-curve of the diffusion process the author explores non linear techniques to estimate it, namely negative binominal regression. The reasons for such a choice are quite obvious. First, according to the simple logic that the adoption of any product measured in terms of the number of users cannot be negative. Second, such "count" variables as the number of hosts can be better fitted by maximum likelihood estimation as the Poisson or negative binomial. The author claims that under the goodness of fit test she had to reject the Poisson specification.

The main findings of the paper confirm that economic competition and social emulation of the "neighbors" play an important role in the global diffusion of the Internet. Although the other three forms of pressure turned out to be less significant the authors believes that network externalities, U.S. hegemony, and learning from being a part of international organization are certainly present in the case of the Internet.

As it can be noticed there are different approaches to pin down the diffusion of the Internet across countries. Both descriptive and empirical studies are considered to be useful in understanding the nature of this process and providing possible solutions for bridging the "digital divide" across countries. At the same time, to the best of our knowledge, there is no study which addresses the issue of bridging the digital divide empirically. Analysis based on empirical approach, which are aimed to determine the main factors of the Internet adoption, utilize some common variables such as GDP per capita and the level of development of Internet infrastructure that are significant through all the studies exploiting different econometric techniques. However, the power of some variables (e.g. investment in telecommunication sector, competition, average years of schooling in a country, etc.) to explain the adoption of the Internet across countries varies from one study to another. The main purpose of this paper is to check whether there exist convergence across countries in terms of Internet diffusion so that digital divide is bridging over time. Therefore, it attempts to determine the main factors influencing the diffusion process of the Internet across countries by utilizing empirical model, namely the Gompertz model, and supplements the results with panel data estimation. Controlling for all explanatory factors assumed by the theory it investigates the main ones and checks the robustness of the results by comparing estimators. The novelty of the paper is that it proves the existence of convergence which leads to the conclusion that digital divide is bridging over time, and countries approach their steady states in terms of the technology adoption. Furthermore, it provides the elasticity of the diffusion of the Internet with respect to the main explanatory factors as costs of connection and GDP per capita in a country.

CHAPTER3.

Data description.

The initial data set consists of statistics for 72 countries around the world and covers the period from 1995 to 2000.Controlling for different factors like costs of connection, regulation in an industry, etc. we have to restrict the actual sample explored in regressions due to the shortage of the data for certain countries and series in a given year. The facts that countries excluded from the initial sample for the purpose of the estimation are primarily ones that do not have any information available regarding the number of Internet hosts/users per capita or any other variables (e.g. "promotion of ICT" or e-readiness), and their GDP's vary enough (that is not only countries with low real GDP per capita is excluded), suggests that actual sample is not subject to selectivity bias.

A substantial part of the data set utilized for the estimation was kindly provided by the International Telecommunication Union. In addition statistics on the telecommunication industry, world development indicators (WDI) from the World Bank, political freedom index from the FreedomHouse, information on regulation in telecommunication industry from OECD international regulation database, the Global Competitiveness Report statistics are used. Variables from the Competitiveness Report are scored on a scale from one to seven; the higher is the score the better particular aspect of the internet is developed.

To determine the diffusion of the Internet across countries, two variables are explored as dependent ones– the number of Internet hosts per capita and the number of Internet users per capita in a country. The reason for this is that each indicator reflects the decision of either individuals or firms whether to adopt the Internet.

The number of Internet hosts in a country represent the supply side of the process thus underlying how many web pages exist in a country. At the same time, being one of the most useful indicators of the development of the Internet infrastructure in a country it does not measure the number of users. Due to this reason it can be considered as a poor indicator while considering accessibility to the Internet. Furthermore, there is no strong consensus on the definition of the host which may include mail servers or other devices that are not very meaningful for analysis. Hosts are supposed to be located in a country which is identified by their Top Level Domain (TLD) – two letter country code. It is not necessarily true in reality since any host under domain edu., org., net., com. can be located anywhere despite their country of origin that is the physical location of the host is not reflected in these three letters and, as a result, can be considered as a proxy for the analysis of the Internet diffusion in a particular country. For instance, most U.S universities and organizations explore exactly these three letters instead of TLD, thus leading to underestimation of the U.S. dominance on the net. That means that the results based on TLD should be interpreted carefully.

The demand side of the process of diffusion is characterized by a number of Internet users in a country. It reflects the fact whether the Internet is demanded by individuals. Although such type of data does not measure actual Internet traffic, that is how much time individuals spend on line.

The reason to include real GDP per capita is that it accounts for income effects that influence different rate of diffusion of the Internet in a country and differences in initial factors' endowment across countries that could be omitted in the other variables (Comin and Hobijn , 2003).

The political freedom index includes political rights and civil liberties in a country and is measured on a one-to seven scale, with the highest degree represented by one and the lowest degree represented by seven. Countries whose index falls between 1.0 and 2.5 are considered as "free"; between 3.0 and 5.5 "partly free" and 7.0 as "not free".

The measure of network externalities is the total number of host/users in the world in year t minus country i itself in the same year (following Milner, 2003).

In order to avoid modeling the initial stage of the diffusion process in each country for the primary analysis we explore only those that had at least 35 Internet hosts by the time of 1995[5].

Most variables utilized in the analysis are highly correlated with each other. Therefore, in order to avoid a problem of multicollinearity we do not consider them simultaneously in one regression – that is the reason why we have several specifications later on.

[5] This assumption will be relaxed later on to check the robustness of the results.

CHAPTER4.

Theoretical background and methodology explored.

4.1.Convergence.

The way to test the existence of cross country convergence in terms of Internet adoption which allows drawing a conclusion whether inequality in access to the net declines over time is to estimate β convergence (absolute and conditional) . According to Sala –i-Martin (1996) β convergence relates to the mobility of individual economies.

Following the classical growth literature we estimate the following specification proposed by Sala –i-Martin (1996) to assess *absolute convergence* across countries in terms of Internet adoption:

$$(1/T)*ln(H_{i,2000}/H_{i,1995}) = \alpha - [(1-e^{-\beta T})/T]*ln\, H_{i,1995} + u_{i\,1995,2000} \qquad (1a)$$

where $u_{i\,1995,2000}$ represents the average of the errors terms, u_{it} , between years 1995 and 2000.

Dependent variable here is an annualized growth rate of the number of Internet hosts/users per capita in a country i; T is the number of periods, which is 5 in our case. Since the specification 1a does not include any additional variable we consider it to be the basic equation to estimate absolute convergence. In so doing we ignore other variables in the growth equation to allow us to check to what extent the diffusion of the Internet is stipulated purely by its initial level. Absolute convergence implies that all countries approach one steady state.

Given a coefficient of $[(1-e^{-\beta T})/T]$ we compute β thus assessing the convergence. If β >0 we conclude that there exits absolute β convergence (based on specification 1a), and divergence otherwise.

To test for the *conditional convergence* (using the methodology proposed by Mankiw at al. (1992)) we need to introduce variables which proxy the differences in the steady state across countries. As a control variable we use logarithm of the GDP per capita in a country. All other variables that we intended to include appeared to be statistically insignificant so we decided to leave just logarithm of GDP per capita. Including this variable, which we believe to be one of the best indicators of the prosperity of a country, we check how income affects the diffusion process. Conditional convergence implies that in contrast to the specification 1a for the purpose of conditional convergence estimation the specification takes the following form:

$$ln(H_{I,2000}/H_{i\,1995}) = \alpha + \beta \, ln\, H_{i\,1995} + \gamma \; lnGDPper\ capita + u_{i\,0,T} \quad (1b)$$

where *lnGDPper capita* represents average for the period 1995-2000

In this case we claim that there exists conditional β convergence (based on specification 1b) if estimated coefficient β <0.

Conditional β convergence implies that countries which stay further from their steady states in terms of the Internet adoption grow faster compared to those which are closer to their steady states.

4.2. Diffusion; the Gompertz model and panel data analysis

As it was mentioned the process of diffusion is characterized by a pattern that follows an S-shaped curve which reflects the fact that the rate of adoption starts at a low level and progresses slowly at first. When time passes the rate of diffusion becomes larger and remains so until the point of inflection, when the rate of adoption still increases but at a falling rate. Ultimately, the adoption of any innovation tends to saturation thus approaching unity.

Griliches (1957) proposed to fit this pattern by the logistic curve with the following formula:

$$P_i(t)=P_i^a/(1+exp(-\eta i-\varphi i*t))$$

$$dP_i(t)/dt=\varphi i\ *P_i(t)\{1-P_i(t/)P_i^a$$

where P_i^a is the saturation point (asymptotic level of use);

ηi locates the diffusion curve on the horizontal axis;

φi is a measure of a speed of transition.

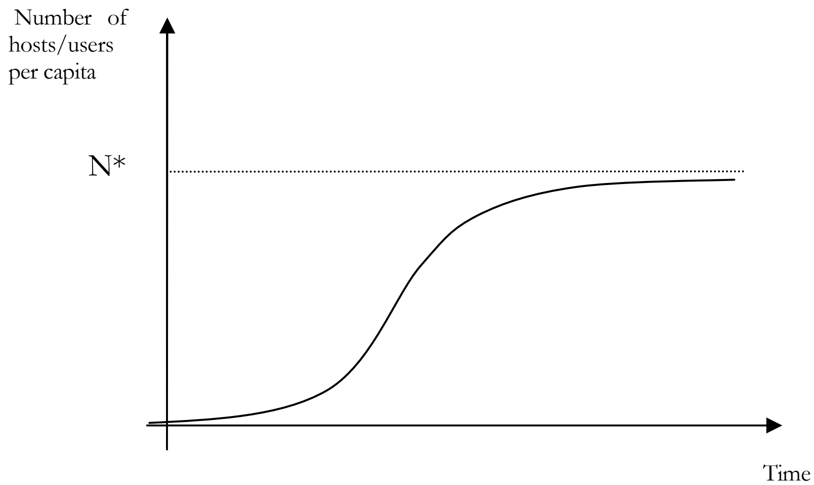

Figure1. The S-shaped diffusion curve.

The probability that country i has the Internet adopted is assumed to be a function of a vector of its characteristics (X_i) that includes telecommunication infrastructure, prices for Internet connection, level of education in a country, etc. As it is suggested by the very basic economics, the quantity of a product/service demanded depends on its price and buyers' income.

The general representation of a model used to describe the diffusion process is as follows:

$$\text{Prob(Internet adoption)}=\Phi(\alpha + \beta Xi)$$

Where Xi's are the coefficients and Φ is a cumulative distribution function (cdf). The type of cdf depends upon the assumption imposed on the distribution of the error term. If it is assumed to have standard normal distribution (e ~ N(0, 1)) – the probit model is estimated; if a logistic distribution is assumed (e $\sim \Lambda\,(1, \frac{\pi\text{^}2}{3})$) –the logit model is estimated.

Long (1997) argues that the choice between the probit and logit models is much more a matter of convention than any other reasons, since "substantive results are generally indistinguishable" and "extremely large samples are necessary to distinguish whether observations were generate by the probit or logit models".

The main drawback of such methodology is that the dependent variable is represented only as 0 or 1 thus leading to the loss of significant part of information. Besides, in the sample at disposal there is no much variation in both dependent variables (the number of hosts/users per capita in a country) if measured in terms of 1 or 0 depending on whether there are hosts and users in a country.

Dixon (1980) suggested that a better representation of the diffusion process is the Gompertz curve which has the following form:

$$dP_i(t)/dt = \varphi i * P_i(t)\{logP_i^a - logP_i(t)\}$$

According to him the main difference between the Gompetz and logistic curve is that the former has an inflection point at $P^*_i/3$ (which seems to be more reasonable) while the latter's inflection point is at $0.5P^*_i$. In addition such approach toward estimation of the diffusion process allows taking into account all information.

The Gompertz model estimated takes the specification proposed by Kiiski and Pohjola (2001):

$$lnH_{it}-lnH_{it-1}=\alpha\ (lnH_{i}^{*}-lnH_{it-1}) \qquad (1)$$

$$\ln H_{it}^{*}=\beta_{i0}+\beta_{i1}\ lnY_{it}+\ \beta_{i2}ln\ P_{it}+\gamma\ Z_{it} \qquad (2)$$

We argue that equilibrium level of Internet hosts/users per capital is a function of basic demand and supply side variables, as Internet access costs and GDP per capita, which vary over time. This makes the level of hosts/users per capita itself to be time-variant so that subscript t appears in the specification (2).

Inserting (2) into (1) we obtain the model to be estimated:

$$lnH_{it}-lnH_{it-1}=\alpha_{I}\ \beta_{i0}+\ \alpha_{I}\ \beta_{i1ln}\ lnY_{it}+\alpha_{I}\ \beta_{i2}\ lnP_{it}+\ \alpha_{I}\ \gamma\ Z_{it}-\ \alpha_{1}\ lnH_{it--1}$$

H_{it} is the number of Internet hosts/users per capita in a country i in the year t;

H_{it}^{*} is the post diffusion (equilibrium) level of Internet host/users per capita in a country i ;

α is a speed of adjustment;

Y_{it} is the level of income in a country i in the year t;

P_{it} is the costs of Internet access;

Z_{it} the vector of any possible variables representing demand or supply conditions of the process of diffusion in a country i in the year t.

The regression equation for regular *panel data analysis* takes the following form (adopted from Comin and Hobijn (2003)):

$$lnH_{it}=\sum_{k=1}^{m}\beta_{k}X_{ikt}+\varepsilon_{it}$$

where X_{ikt} for $k = 1,\ldots, m$ are potential determinants of Internet diffusion in a country;

H_{it} is the number of Internet hosts/users per capita in a country i in the year t.

Comin and Hobijn (2003) do not consider simultaneity bias to be a problem in this specification since it attempts to pin down the diffusion of technology – the Internet – which has micro origin by considering general macroeconomic factors that might influence the decision whether to adopt it. In fact, this is the only paper that we are familiar with which mentions possibility for such a problem as endogeneity to exist, even though it does not deal with it directly.

In fact, to be able to solve the problem of endogeneity one needs to utilize instruments for almost all the explanatory variables that enter the regression. This is not an easy task to conduct since proper instruments either do not exist or difficult to find. Taking into account these types of concerns it would be more correct to talk about correlation between the explanatory factors and the number of Internet hosts/users rather than about causality.

While conducting estimations based on the sample of 72 countries, we impose several assumptions.

Assumption # 1. Countries that had at least 35 Internet hosts by year 1995 enter the sample so that we avoid modeling the initial stage of the diffusion process. Differences across countries in term of the Internet development are quite significant; at the time when there were several hundreds users in U.S. and Western Europe the Internet just started spreading across the remaining countries of the world. Furthermore, a caveat of our data set is that it does not contain much information on the Internet diffusion during its introductory stage.

Assumption # 2. Population structure is identical across all the countries. It appears logical that young people use the Internet more frequently than old people do. Given that some countries are tend to have more old people as a percentage of total population this assumption is reasonable.

Assumption # 3. The speed of adjustment α is constant over time.

Assumption # 4. There is a long run equilibrium level of Internet hosts/users in each country H*. Furthermore, since this long run equilibrium level depends on the basic demand side factors such as Internet access costs P_{it} and GDP per capita Y_{it} which vary over time, H_i^* is also considered to be time-variant.

CHAPTER5.

Estimation results and analysis.

5.1.Convergence.

The results obtained from the basic equation (table 1), suggest the following: there exists absolute convergence of the Internet across countries measured both in terms of the number of hosts per capita and users per capita (all beta's are positive). R squares for both cases also differ much and account for 9.89% and 59.48% respectively. The speed of convergence toward steady state is different; in the case of Internet hosts it is 2.48% in a year, while for Internet users it is comparably higher – 9.2 %[6] in a year. These figures suggest that each year the gap between "haves" and "have-nots' in terms of the Internet adoption decreases by 2.48% and 9.2% so that the digital divide becomes smaller over time. To make a vivid example we can claim that it would take a country with poorly developed Internet, say Albania[7], about 40 year to reach steady state. At the same time, one should keep in mind that this conclusion is valid if we assume that the convergence remains the same during the years which it takes for a country to arrive at the steady state. It would be logical to suppose that the convergence occurs not linearly but rather decreases over time. That means that poor countries start developing very fast but when time passes the speed of development slows down. In the light of such an assumption, it would be reasonable to assume that Albania will need not 40 years but a somewhat longer period to approach steady state.

[6] Identical results can be obtained with the specification proposed by Comin and Hobijn (2003) which does not require annualized growth rate of the Internet diffusion and takes the following form: $lnH_{it} = \alpha + \beta \, lnH_{it-T} + other\ variables + \varepsilon_{it}$

Having added a control variable of logarithm of GDP per capita we, observe different results. Since values of the additional variable vary across countries we have conditional convergence. This might provide an explanation why estimated speed of convergence doubles (4.8%) and R^2 becomes 13.6%. It means that accounting for the differences across countries in terms of their income theis a faster speed with which a country approaches its steady state. A higher R^2 suggests such a specification being better one to explain the convergence in terms of Internet hosts. This indicator is even higher when we talk about Internet users – 12.9% and 74.6% respectively.

The fact that diffusion of the Internet in terms of users occurs much faster could be explained by the fact that it is relatively easier for an individual to become a user than for a host to be set. Besides, such a difference may be due to the problems with the preciseness of Internet users' measurement – both frequent users and those who went on-line accidentally are treated equally while evaluating the number of Internet users; in fact, it is hard to distinguish between them.

To be sure about the robustness of the results we conduct several diagnostic and specification tests which deal with the restrictions on coefficients, omitted variables, and redundant variables. The reason why we apply these tests to the specification aimed to assess conditional convergence is that according to the classical approach it should contain all basic variables which reflect differences across countries. However, as it was mentioned above, in our case all the control variable (except for *lnGDPper capita*) appear to be statistically insignificant so their inclusion does not provide much information.

It is known that specification error (which includes omission of the relevant independent variable, incorrect functional form, and correlation between explanatory variable and error term) leads to baised and inconsistent estimates.

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[7] According to International Telecommunication Union (ITU) Albania had 0.43 Internet hosts per 10000 inhabitants in 2001.

Therefore, to be able to claim the unbaisness and consistence of our estimates we explore Ramsey regression specification test (RESET). The results obtained suggest that we cannot reject H_0 that the model has no omitted variable at a 1% significance level. (See Appendix A)

Table1. Speed of convergence, estimates of β

	1 basic equation (absolute convergence)			2 equation with control variable (conditional convergence)	
in terms of:	estimate of $[(1-e^{(-\beta T)})/5]$	β	R^2	β	R^2
# of hosts per capita	-0.023	**0.024**	0.098	**-0.048**	0.136
# of users per capita	-0.073	**0.092**	0.594	**-0.129**	0.746

N=72

Repeating the same procedures for the case of Internet users per capita we obtain similar results, namely, Ramsey specification test supports a story that the model has no omitted variable at 10% significance level. (See Appendix A)

In addition to formal way to test the robustness of the estimates by exploring specification and diagnostic tests we provide the results obtained by playing with the cut-off point of the initial level of Internet hosts in a country changing it from 35 to 100 and 500.

Relaxing the assumption about the initial level of the Internet hosts/users in a country by year 1995 (increasing it to 100 and 500) does not change the general pattern of convergence occurring; namely, the speed of absolute convergence is slower than that of the conditional one. Although this step reduces the sample size it provides higher R^2's. (See Appendix B)

Comparing our results regarding the speed of conditional convergence across countries in terms of the Internet adoption with the results by Comin and Hobijn (2003), who studied cross-country information technology adoption in terms of personal computers per capita and found it to be 8.33% for the entire post second world war period, we may conclude that diffusion of the Internet occurs at much faster pace. The only industry which shows relatively high speed of convergence for the entire period – 24.84% - is the mass communication industry which includes newspapers per capita, radios per capita, and televisions per capita.

5.2. The Gompertz model

The results obtained from the basic equation (Table 2, regression 1), the one without any control variables but only the main demand indicators – GDP per capita and Internet access costs, suggest that what matters most for the diffusion process is the level of income per capita in a country and its initial level of the Internet development. We should keep in mind that the speed of adjustment α_1 = 0.207 has to be accounted for while interpreting the coefficients.

Table2. The Gompertz model estimation (number of hosts per capita)

	1	2	3	4	5	6
Constant, $\alpha_1 \beta_0$	-1.510 (1.927)	-1.703 (2.119)	-2.112 (2.200)	-1.552 (2.253)	0.039 (0.117)	1.863 (5.614)
Speed of adjustment α_1	**0.207*** (0.085)	**0.216**** (0.085)	**0.250*** (0.088)	**0.234*** (0.091)	**0.143***** (0.086)	**0.224**** (0.098)
GDP per capita $\alpha_1 \beta_1$	**0.260***** (0.155)	**.423**** (0.181)	**0.349***** (0.201)	**0.464*** (0.182)	**0.442*** (0.175)	**0.431**** (0.179)
Internet access costs $\alpha_1 \beta_2$	-0.052 (0.058)	**-0.116***** (0.069)	-0.062 (.073)	-0.103 (0.072)	-0.101 (0.065)	**-0.122***** (0.069)
Main telephone lines in operation		0.004 (0.003)			**0.005***** (0.003)	
Political freedom		0.064 0.047				
Promotion of ICT by the Government		**-0.399*** (0.130)		**-0.402*** (0.135)		**-0.461**** (0.137)
Competition			-.002 (0.158)			
Legislation on ICT					**-0.654*** (0.166)	
Network externalities effect						-1.777 (3.066)
Secondary school enrolment				0.003 (0.006)		
R^2	0.145	0.370	0.227	0.333	0.407	0.366
Number of observations	72	61	61	61	62	61

Note: standard errors are in parentheses; * - significant at 1%; ** significant at 5%; *** - significant at 10%

When we account for other factors that influence the diffusion process (regressions 2-6) we observe several changes compared to the basic results. Thus, including a variable that captures the effect of the Government promotion of ICT in a country[8] turns Internet access costs to be significant. Besides, such a specification (2) provides higher R^2 for our model. The effect of the promotion of the Internet in a country on the entire diffusion process seems to be of paramount importance. A negative sign of the coefficient reflects the very nature of the word "promotion". In this case, promotion includes different legislation on ICT, which might be restrictive to some extent. Thus, for instance, it might be mandatory requirement for an ISP to register so that they have to go through cumbersome procedures; the existence of over preventive law related to the issue of electronic signature, etc. Including the legislation on ICT as a separate regressor, we find it to be highly statistically significant and remaining negative.

The factor "years of schooling" turned out to be insignificant thus contradicting the belief that the more educated people in a country the better it is for the diffusion of the Internet. In fact, when we think about the usage of the Internet without going into deep technical details (which is most users do) it might not require fundamental understanding. This fact makes the level of education irrelevant to some extent. Our finding regarding "years of schooling" coincide with that of Kiiski and Pohjola (2001).

Neither competition within the ICT sector, nor political freedom in a country, is statistically significant. These are rather surprising results since it would be logical to assume that the more competitive the industry is the more consumers benefit because of emulation between Internet Services Providers (ISP). The results regarding political environment in a country suggest that the type of authority does not influence the diffusion process *per se*.

[8] Promotion of ICT includes existence of law related to ICT, electronic signature, etc.

One more factor, which we found to be statistically significant in one of the regressions (5), is "main telephone lines in operation" which represents the level of the infrastructure development in a country. However, it is significant only marginally (p value is close to 10%). It can be explained by the fact that the Internet is permanently developing technology, and such way of connection as broadband (which does not require the telephone line) is becoming more and more popular as a replacement to a dial-up connection.(Forrester, 2002)

Controlling for the effect of network externalities (the total number of Internet hosts minus the number of Internet hosts in a given country) we do not find it to be statistically significant. This finding (insignificance of network externalities) is similar to that of Milner (2003). Since the dependent variable in this specification is "the number of hosts", we can explain it by the fact that people who set Internet host do not take into account how many hosts already exist. Their main concern is the size of the network measured in terms of users that is how many people are actually on-line and considered as their potential visitors. At the same time, it is quite surprising to observe negative sign of the network externalities effect's coefficient. By definition network externalities effect brings more value to each member of the net as the number of members increases. However, since this coefficient appears to be insignificant we do not think it is worth considering here in details.

In general, estimation has expected results in that it shows importance of income level, access costs and infrastructure development for the diffusion of the Internet; all the coefficients have logically explainable signs. Furthermore, it suggests that level of government supervision of the ICT industry has an impact on technology adoption.

Analysis in terms of Internet users shows that a general pattern of the significance of explanatory variables remains the same (Table 3.) Such factors as GDP per capita, initial size of the network represented by the number of user per capita in 1995, and government promotion of ICT turned to be statistically significant trough all the regressions. In contract to the previous analysis, neither variable reflecting existence of the legislation on ICT nor "main telephone lines in operation" seems to be important for the individuals while deciding upon the adoption of the Internet. It might be due to the fact that individuals do not care much about the underlying juridical aspects of the Internet functioning unless it concerns something which is directly related to them – legislation that guarantees security while shopping on-line, etc. However, in this case the coefficients have positive sign, which implies that the more legislation is the better it is for users. This conclusion is based on the assumption that laws are aimed to protect users while deciding upon connection or being on-line. The same reasoning as with the case of the dependent variable being "the number of hosts" can be applied to explain the finding that infrastructure development measured by the main telephone lines in operation does not influence the diffusion process; broadband connection is replacing dial-up.

One more coincidence with the preceding analysis is the fact that in this specification network externalities affect appeared to be statistically insignificant with negative sign of the coefficient. This result is quite unexpected since the more people use the Internet the higher benefits for each of them. Having just an access to the Internet has little value in itself and does not generate utility for a user. It is a platform for sharing ideas, obtaining information and education, making business that is all types of activities that require presence of other people. As a result, the more people the better. Surprisingly, the data does not prove this to be the case.

One of the unexpected findings is that Internet access costs have appeared to be insignificant in all the specifications but (5) and (6).

Speed of adjustment if measured in terms of Internet users is also higher than in case of hosts. This result coincides with the one of estimated convergence as proposed by Sala-i-Martin (1996). Explanation of this phenomenon is the same as in the case of convergence.

Driven by the same reason as in the case of convergence estimation we relax the assumption about the initial level of Internet adoption in a country by 1995 if measured by the absolute number of Internet hosts. Thus, we repeat the estimation playing with the cut-off point of the number of Internet hosts by changing it from 35 to 100 and 500 so that we can draw a conclusion about the robustness of the results. We should stress that general pattern of explanatory factors' significance, in particular such main variables as GDP per capita and connectivity costs, remains the same. What has changed is the speed of adjustment, which becomes higher in all specifications. This finding could be explained by the fact that an increasing the number of Internet hosts in a country by 1995 we automatically shift to the steep part of S-shaped curve where diffusion occurs much faster which is reflected by higher speed of adjustment. In addition to the primary analysis each specification estimated on a basis of modified sample provides higher R^2. Furthermore, network externalities effect becomes marginally significant which is more logic when we think about the Internet.

In summary, the results obtained are expected and logical – GDP per capita has positive sign through all the regressions, government promotion of ICT is appreciated by users; unexpected result concerns statistical insignificance of Internet access costs. The main findings remain the same while checking for their robustness by playing with the cut-off point of the initial level of the Internet adoption in a country. Furthermore, speed of adjustment in case of the Gompertz model is similar to the speed of estimated conditional convergence.

Table3. The Gompertz model estimation (number of users per capita)

	1	2	3	4	5	6
Constant $\alpha_1 \beta_0$	**-4.591*** (0.944)	**-6.141*** (1.013)	**-5.567*** (1.001)	**-6.311*** (0.993)	**-6.160*** (1.006)	**3.812*** (5.459)
Speed of adjustment α_1	**0.603*** (0.054)	0.700 (0.051)	**0.685*** (0.052)	**0.716*** (0.051)	**0.720*** (0.053)	**.284**** (.088)
GDP per capita $\alpha_1 \beta_1$	**0.495*** (0.078)	**0.538*** (0.087)	**0.522*** (0.095)	**0.508*** (0.085)	**0.512*** (0.088)	**.450**** (.180)
Internet access costs $\alpha_1 \beta_2$	-0.050 (0.032)	-0.039 (0.035)	-0.044 (0.037)	-0.050 (0.036)	**-0.046*** (0.035)	**-.112***** (.070)
Main telephone lines in operation		-0.000 (0.001)			-0.000 (0.001)	
Political freedom		0.014 (0.024)				
Promotion of ICT by the Government		**0.166*** (0.068)		**0.179*** (0.068)		**.407*** (.132)
Competition			0.075 (0.079)			
Network externalities effect						-3.298 (2.866)
Legislation on ICT					**0.207**** (0.089)	
Secondary school enrolment				0.003 (0.002)		
R^2	(0.748)	(0.844)	(0.826)	(0.848)	(0.829)	(0.346)
Number of observations	72	61	61	61	61	61

Note: standard errors are in parentheses; * - significant at 1%; ** significant at 5%; *** - significant at 10%

5.3. Panel data estimation

First we should emphasize that panel data are not available for all of the series utilized for the previous analysis of the convergence and the Gompertz model. In particular, such information as government success in promotion of ICT, existence of legislation on ICT, competition within the industry, and some others are not available through the period under study.

One more problem arises with respect to the data on the Internet access costs. As it is stressed by Kiiski and Pohjola (2003) "the methodology of estimating the costs has been changed over the years, but the time series has not been harmonized". As a result, we replace Internet access costs with telephone tariffs provided by International Telecommunication Union (ITU). However, this action brings additional problems which will be elaborated on in more details later on.

The main problem with the panel data at disposal is that almost all the series appear to be highly correlated with each other. Even such basic factors representing demand and supply sides of the diffusion process as GDP per capita and telephone tariffs are highly correlated. Therefore, we cannot distinguish between the effects made by each variable.

As a result, panel data analysis suffering from this type of flaws cannot be considered as a major source. The only reason to conduct it is to check the significance of each factor which, we believe, might influence the diffusion of the Internet across countries, one by one, and provide the robustness analysis of the previous findings.

In order to decide upon what model to explore – fixed effects or random effects – we conduct Hausman test for the specifications which we have chosen as being suitable for the estimation. The results of Hausman test suggests that in both cases fixed effects model is appropriate; Hausman statistics leads to rejection of null hypothesis, so that fixed effects model is preferred.

Panel data analysis proves the results obtained utilizing the Gompertz model in that it shows that education in terms of secondary school enrolment is insignificant for the diffusion of the Internet. The underlying reasoning behind this finding was elaborated on in details above. In order not to repeat ourselves we could complete the discussion about the education impact on the diffusion of the Internet by saying that our finding coincides with that of Kiiski and Pohjola (2001) and contradicts the one by Avi Goldfarb (2004) who finds positive impact of university attendance on the diffusion of the Internet.

Other variables included into the panel data estimation - ; "main telephone lines in operation", "network externalities effect", and "political freedom" - prove to be significant. However, if significance of the level of the Internet infrastructure development remains the same for the explanation of the Internet adoption as in the previous analysis, political freedom in a country becomes significant only in the panel data estimation. The sign of the coefficient (given the way it is measured) is negative as was expected. It means that the less political freedom in a country the worse it is for the diffusion of the Internet.

One more result which does not coincide with the one from the Gompertz model is that the network externalities effect turns out to be significant for the adoption of the technology. This finding supports our initial hypothesis about increasing value of the Internet for individuals with increase in the number of its member.

Table4. Panel data estimation (the number of Internet hosts per capita)

	1	2
Constant	**-7.212**** (0.342)	**-8.234*** **(0.399)**
Main telephone lines in operation	**0.012**** (0.005)	**0.012**** (0.005)
Secondary school enrolment		0.004 0.004
Political freedom	**-0.152*** (0.059)	
Network externalities effect	**1.426*** (0.052)	**1.413*** (0.053)
R^2	0.139	0.723
# of observations	432	432

Note: * - significant at 1% significance level; ** - significant at 5% significance level;*** - significant at 10% significance level.

Replacing the dependent variable "the number of hosts per capita" by "the number of users per capita" does not change general pattern of factors' significance, except for "secondary school enrolment" and "political freedom" – the former becomes marginally significant while the later loses its statistical significance. Level of infrastructure development remains important in explaining the diffusion of the Internet.

Table5. Panel data estimation (the number of Internet users per capita)

	1	2
Constant	**-6.777*** (0.401)	**-5.902*** (0.292)
Main telephone lines in operation	**0.023*** (0.005)	**0.023*** (0.005)
Secondary school enrolment	**0.008***** (0.004)	
Political freedom		-0.041 (0.068)
Network externalities effect	**1.943*** (0.537)	**1.976*** (0.050)
R^2	0.834	0.833
# of observations	432	432

Note: * - significant at 1% significance level; ** - significant at 5% significance level;*** - significant at 10% significance level.

CHAPTER6.

Conclusions.

The goal of the paper is to pin down the diffusion of the Internet by exploring the main factors influencing the decision of individuals whether to adopt the technology with the help of macro data. It is an attempt to assess the main determinants that caused the Internet to flourish in high developed countries and that might be useful to be learned by policy makers in less developed countries to be paid attention at. The study addresses the issue of "digital divide" and its possible bridging over time. It proves that convergence across countries in terms of Internet adoption exists, thus reducing the "digital divide". This finding implies that the gap between "haves" and "have-nots" in terms of Internet development might disappear over time or, at least, will not become larger.

The initial hypotheses of the paper are that countries with higher income per capita lower Internet access costs, with well developed infrastructure of telecommunication industry, high standards of education in society and elaborated legislation of ICT sector are more likely to have higher rate of diffusion of the Internet. Adequate considerations of all these factors lead to the fact that countries converge to a steady state in terms of Internet adoption (both in absolute and conditional terms).

Having conducted the analysis we may conclude that there exists convergence – both absolute and conditional - across countries in terms of Internet hosts/users per capita. This means that the "digital divide" caused by disparities between countries is being bridged by the means of Internet diffusion. We found the speed of diffusion to be lower for the absolute convergence – both for the case of Internet hosts per capita and Internet users per capita. Controlling for differences across countries (conditional convergence) we found that the speed of diffusion becomes higher. This indicates the fact that the further each country stays from its steady state the faster it approaches it (ceteris paribus).

Given the estimated results we may conclude that initial hypotheses regarding the Internet diffusion are showed to hold in most specifications. Thus, income per capita, Internet access costs, Internet infrastructure development and existence of legislation related to ICT explain the diffusion process best; all these factors appeared to be highly statistically significant. However, their impact is different and depends on what we consider as a measure of the diffusion – the number of Internet hosts per capita or the number of Internet users per capita in a country. The data shows that the existence of over preventive legislation about ICT negatively effects computer hosts, but does it positively in the case of Internet users. The level of Internet infrastructure development measured by the number of main telephone lines in operation turns to be important in panel data estimation and only in a few specifications of the Gompertz model. We explain this phenomenon by the fact that dial-up connections are being replaced by broadband connection. Internet access costs and the level of income -- two major demand side factors – are also significant.

Surprisingly, different approaches (the Gompertz model and panel data estimation) provide contradictive results with respect to such factors as political freedom, education in a country and network externalities effect. Their significance and signs vary from one specification to another, from one approach to another. In the Gompertz model network externalities effect is insignificant and negative, which is rather unexpected following the nature of the Internet. At the same time, panel data estimation suggests somewhat more logical result – network effect is of paramount importance for the diffusion of the Internet and enters the regression with the positive sign.

The paper provides strong empirical evidence that disparities across countries in terms of the Internet adoption represented by the "digital divide" and consequent "information poverty" might be reduced by paying more attention by policy makers at GDP per capita, Internet access costs, level of the infrastructure development, promotion of the Internet and ICT, in general, education of society and political environment. It goes without saying that today Information and Communication Technologies (ICT), and the Internet as its main part, affect societies. Therefore, the question of "whether" is smoothly transforming into the more important question of "how". How does the Internet diffuse across countries so that some of them can reap economic and social benefits that it brings while the others lag behind? How does the Internet promote more democratic societies? How does the Internet cause inequality and social exclusion? Among these "how" questions we would like to single out the one of vital importance – "how to bridge the digital divide which occurs as a result of uneven adoption of the technology". What policies should be undertaken by the policy makers around the world in order to guarantee that everybody has an equal access to the Internet and there is no exclusion?

Having conducted the analysis we may suggest the following:

1. There should be prudent level of regulation with respect to the Internet. Individuals should feel legally protected while being on-line. At the same time, highly restrictive government policies regarding censorship and privacy will hamper the diffusion of the Internet.

2. The underlying infrastructure of the telecommunication sector is important. Although wireless Internet is becoming more popular, most people in less developed countries, "have-nots", are still dependent on dial-up connections to the Internet, and will remain so in the nearest

future. Provision and maintenance of high quality telephone lines and the size of the network is crucial in this aspect.

3. There should be projects aimed at the reduction of Internet connectivity costs. Policies with the main purpose to decrease Internet access costs, either through the exemption of Internet Services Providers (ISP) from tax payments or direct funding of content providers, will guarantee that more people reach the Internet.

4. Effective measures to promote non-commercial use of the Internet should be adopted given the fact that the speed of convergence is much higher in the case of Internet users. This might include introduction of the Internet in public schools as well as actions undertaken by non-governmental organizations (NGOs) regarding teaching of basic Internet usage literacy in order to achieve widespread usage of the Internet.

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APPENDIX A.

Table1. Ramsey specification test (RESET) for the case of conditional convergence

In terms of	statistics	p-value	Decision
# of Internet hosts per capita	7.20	0.0003	Cannot reject H_0 :the model has no omitted variable at 1% significance level
# of internet users per capita	2.25	0.0904	Cannot reject H_0 :the model has no omitted variable at 10% significance level

APPENDIX B.

Table2. Speed of convergence, estimates of β, the number of hosts in 1995 equals 100

	1 basic equation			2 equation with control variable	
in terms of:	estimate of $[(1- e^{(-\beta T)})/5]$	β	R^2	β	R^2
# of hosts per capita	-.0344	**0.037**	0.2729	**-0.055**	0.3109
# of users per capita	-.0518	**0.059**	0.3030	**-0.133**	0.8130

N=65

Table3. Speed of convergence, estimates of β, the number of hosts in 1995 equals 500

	1 basic equation			2 equation with control variable	
in terms of:	estimate of $[(1- e^{(-\beta T)})/5]$	β	R^2	β	R^2
# of hosts per capita	-.0418	**0.0469**	0.3977	**-0.066**	0.4381
# of users per capita	-.0814	**0.1046**	0.6628	**-0.133**	0.7757

N=56

APPENDIX C

Table4. The Gompertz model estimation (initial number of hosts per capita equals 100).

	1	2	3	4	5	6
Constant	-1.204 (0.045)	**-3.438**** (1.664)	**-3.595**** (1.56)	**-4.145**** (1.779)	-2.350 (1.679)	2.880 (4.137)
Speed of adjustment	**0.242*** (0.068)	**0.305*** (0.068)	**0.330*** (0.064)	**0.352*** (0.073)	**0.268*** (0.070)	**0.380*** (0.085)
GDP per capita	**0.200***** (0.123)	**0.451*** (0.138)	**0.434*** (0.149)	**0.470*** (0.136)	**0.474*** (0.135)	**0.469*** (0.136)
Internet access costs	-0.03 (1.513)	**-0.097**** (0.051)	-0.069 (0.050)	**-0.102**** (0.053)	**-0.096**** (0.049)	**-0.091**** (0.051)
Main telephone lines in operation		0.003 (0.002)			0.003 (0.002)	
Political freedom		0.047 0.035				
Promotion of ICT by the Government		-0.150 (0.103)		-0.120 (0.107)		-0.160 (0.11)
Competition			-0.060 (0.111)			
Network externalities effect						**3.785**** (2.306)
Legislation on ICT					-0.347** (0.130)	
Secondary school enrolment				0.003 (0.005)		
R^2	0.31	0.512	0.472	0.489	0.54	0.513
Number of observations	65	57	57	57	57	57

Note: * - significant at 1% significance level; ** - significant at 5% significance level;*** - significant at 10% significance level.

APPENDIX D

Table5. The Gompertz model estimation (initial number of hosts per capita equals 500).

	1	2	3	4	5	6
Constant	-2.333	**-3.617****	**-3.652****	**-3.937****	-2.542	4.932
	(1.674)	(1.683)	(1.536)	(1.832)	(1.690)	(3.953)
Speed of adjustment	**.337***	**.327***	.353	**.362***	**.296***	**.472***
	(.071)	(.068)	(.062)	(.072)	(.070)	(.086)
GDP per capita	**.252****	**.442***	**.398***	**.462***	**.465***	**.473***
	(.139)	(.138)	(.143)	(.137)	(.134)	(.132)
Internet access costs	.025	-.080	-.050	-.079	**-.079*****	-.060
	(.044)	(.049)	(.048)	(.052)	(.047)	(.048)
Main telephone lines in operation		.002			(.002)	
		(.002)			(.002)	
Political freedom		.0443				
		.0353				
Promotion of ICT by the Government		-.122		-.108		-.084
		(.101)		(.105)		(.106)
Competition			(-.009)			
			(.107)			
Network externalities effect						**5.442****
						(2.220)
Legislation on ICT					-.323	
					(.127)	
Secondary school enrolment				.000		
				(.004)		
R^2	0.443	0.561	0.537	0.540	0.593	0.593
Number of observations	65	57	57	57	57	57

Note: * - significant at 1% significance level; ** - significant at 5% significance level;*** - significant at 10% significance level.