The Digital Divide in Romania – A Statistical Analysis

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ABSTRACT
The digital divide is a subject of major importance in the current economic circumstances in which Information and Communication Technologies (ICT) are seen as a significant determinant of increasing the domestic competitiveness and contribute to better life quality. Latest international reports regarding various aspects of ICT usage in modern society reveal a decrease of overall digital disparity towards the average trends of the worldwide ITC's sector – this relates to latest advances of mobile and computer penetration rates, both for personal use and for households/ business. In Romania, the low starting point in the development of economy and society in the ICT direction was, in some extent, compensated by the rapid annual growth of the last decade. Even with these dynamic developments, the statistical data still indicate poor positions in European Union hierarchy; in this respect, the prospects of a rapid recovery of the low performance of the Romanian ICT endowment and usage and the issue continue to be regarded as a challenge for progress in economic and societal terms. The paper presents several methods for assessing the current state of ICT related aspects in terms of Internet usage based on the latest data provided by international databases. The current position of Romanian economy is judged according to several economy using statistical methods based on variability measurements: the descriptive statistics indicators, static measures of disparities and distance metrics.

KEYWORDS*: digital divide, statistical indicators, Romania*

JEL CLASSIFICATION: *O33,A14*

INTRODUCTION

The digital divide has been defined as "*the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities*" (OECD, 2001).

Digital divide tackles the social and economical differences among population segments or communities that benefit from having or not having access to reasonable computer equipment (in terms of quality status and costs) and Internet. It refers to the unequal access by some members of society to information and communications technology (ICT) and, in

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the last years, the old-stated divide was readdressed in terms of the unequal acquisition of related digital skills. Lately, the public attention is driven to this challenge named *second digital divide* as derived from the misbalance of the required computer and language skills of the population. The lack of attainment of the digital skills is seen as a major obstacle in preparing the workforce for the XXI century if is considered the increased demand on ICT-related skills and competencies and the short supply offered by the formal education and training programs. Even in those countries where ICT infrastructure has been improved, ICT-driven impacts on competitiveness and well-being trail behind, resulting in a new digital divide (NRI 2012).

The concept of digital divide has received in the last years a great importance in dealing with growth strategy at the national or regional level. Many points of interest derive from the political prospective as the both politicians and domestic administrators are interested in reducing the digital gap by finding the most effective tools in terms of social welfare. There is a major difficulty to measure the real extent of the digital divide, having in view the various reasons for growing this fracture (of economic, social, cultural and infrastructure reasons). The interest of evaluation the size of the discrepancy of a specific country as compared to the performers in the field is given by the benefits of pointing out the aspects in which the country lags or fails to enroll in the trends. Being a complex phenomenon, the measuring of digital divide supposes a multiple facets approach, which involves various procedures of aggregations; it also involves a time prospective as the technological advance is associated, by evidence, with shortening of the gap in the endowments dispersion in ITC devices and, with an increased readiness of population in using the internet information facility for personal and professional purposes.

1. MEASURING THE DIGITAL DIVIDE

The term of digital divide was brought to the public attention starting with 1990s in parallel with the exponential Internet penetration rate through out the world and since then has called even more public consciousness. The digital divide (DD) is seen as a relative concept as its design is meant to compare the ICT development progresses of a country within a group of countries, at a certain point/interval of time.

Starting from the evidence that the access to ICTs is the origin of the digital divide, the subject is intensely approached by the literature using indicators and measures of access and usage of Internet regardless by mean of computer or the mobile telephones/devices – from reports of some international organizations to consultancy companies and institutions. In the paper, we are referring as previously approaches of the digital divide issue only some authors that addressed the methodological issues and metrics for quantifying the phenomenon.

Mehra (2004) (cited by wikipedia or New World Encyclopedia) named four crucial components that foster the disparity in the ICT regime: socioeconomic status (income, highest education level attained, race) associated with state of technological infrastructure.
Corrocher and Ordanini (2002) identified several measurement methods more appropriate to specific stage of the progress of the digital divide (enlisting: early adoption, maturation and massive exploitation of the computer and mobile phones tools) such as: the speed of adoption, the intensity of adoption, and the impact of digitization.

The importance of involving multiple dimensions of the ICTs which result in different impacts on economy and society has been acknowledged by Kauffman and Kumar (2005) and supported the idea of usage of composite metrics.

According to Dasgupta (2001), another technique was proposed based on time series studies that have been limited to examining factors causing increased Internet penetration and telecommunications infrastructure development.

Sicherl (2004) opened a distinctive manner to look up for statistical measure in a dynamic gap analysis where in comparison procedure were used the levels of variable (as identifiers and time related). For example, in digital divide, by time distance approach the result take the form of various measures estimating the lag behind a benchmark country or region in terms of ICT development indicators in terms of number of years a country or region by.
The article of Vehovar et. al. (2006) extended the measurements reduced to comparisons of Internet penetration rates to the bivariate comparisons with the purpose of presenting a general warning against an oversimplified methodological approach to digital divide studies.

2. STATISTICAL OVERVIEW OF ROMANIA IN MEASURING THE DIGITAL DIVIDE

Even from the 2007 edition, the *World Information Society Report* pointed out that the digital divide is shrinking in most technologies, especially mobile telephony, but that limitations in the availability and affordability of broadband remain a cause for concern. The 2011 report uses the WSIS's evaluation methodologies to measure "opportunity" in access to ICTs, using the Digital Opportunity Index (DOI), Digital Opportunity Platform, and the ITU's ICT Opportunity Index (ICT-OI).

Although broadband is now available in 170 economies by the start of 2007, it remains at least ten times more expensive in low-income countries than in high-income countries and is often unavailable outside urban areas. In fact, the digital divide is a complex problem that manifests itself in different ways in different countries. It presents both practical and policy challenges. Moreover, it is apparent that solutions which work in developed countries cannot simply be transplanted to developing country environments: solutions must be based on an understanding of local needs and conditions.

An important experience of developed countries is that the problem of the digital divide persists even in periods when ICT penetration in society is high, since new technologies and tools (e.g. broadband, mobile devices, Web 2.0, etc.) enter the markets, generating new lines of division. In addition to the usage verses non-usage dichotomy, the different skills of the users form an equally significant factor, which is mostly manifested in the dimensions of digital literacy, online self-expression skills, and network-thinking and problem-solving skills.

Using the aggregate measurement - the composite index

A composite indicator is a single real-valued metric which is derived from a set of indicator components by some (mostly linear) aggregation method. A typical composite indicator will take the form:

$$I = \sum_{i=1}^{n} w_i \cdot X_i \qquad (1)$$

where:

I is the composite index, X_i is the normalized values of the variable and w_i is the weight of the X_i, under the constraint $\sum_{i=1}^{n} w_i = 1$ and $0 \le w_i \le 1$ for $i \in \{1,2,...n\}$. Variables need to be standardized or normalized before they are aggregated into composite indicators.

In the following there are presented the main indexes concerning the digital divide or some more general aspects of the ICT current state (table 1).

Table 1. The common used compound digital divide indexes and ICT measures

Index	**Short description**
Orbicom's Infostate Index	DD is seen as the relative difference in the sample countries, benchmarked against a hypothetical country – obtained as the simple average of all countries included in analysis. Those that performed above-average were assigned a positive number, and those that performed below-average were identified by a negative number. The conceptual framework of the index introduces the notions of a country's infodensity and info-use. Infodensity refers to the stocks of ICT capital and labour, including networks and ICT skills, indicative of a country's productive capacity and indispensable to function in an Information Society. It includes ICT networks, machinery, and equipment, as well as ICT skills, indispensable for the functioning of information, knowledge-oriented societies. Info-use refers to the uptake and consumption flows of ICTs, as well as their intensity of use by households, businesses and governments and the intensity of their actual use. Infostate is an aggregation of Infodensity and Info-use indexes and represents the degree of a country's 'ICT-ization'. The Digital Divide is then defined as the relative difference in infostates among economies.
	*Orbicom (*the international Network of UNESCO Chairs in Communications*) Monitoring the Digital Divide* (2003)
ICT Opportunity Index,	The ICT Opportunity Index is the merger of two wellknown initiatives, ITU's Digital Access Index (DAI) and Orbicom's Monitoring the Digital Divide/ Infostate conceptual framework and model.
	ITU, International Telecommunication Unit in "From the Digital Divide to Digital Opportunities: Measuring Infostates for Development".
Digital Divide Index (DDI)	DDI is a composite measure developed by a European Community (EC); it was developed within the SIBIS project (Statistical Indicators Benchmarking Information Society), an EC funded program. As a multi-dimensional measurement, the DDI is built on four dimensions: gender, age, education and income, measuring the access and usage of computers and the Internet. Each sub-index describes the percentage of internet and computer users (total users and "at home") at the risk group as a ratio of the percentage of users in the total population.

Networked Readiness Index (NRI)	The main drivers of a rapidly changing ICT industry and remains relevant for public- and private-sector decision-makers.
ICT Development Index (IDI) (previously known as the Digital Opportunity Index)	It is a valuable tool for benchmarking the most important indicators for measuring the Information Society. It describes the evolution of the information society as it goes through its different stages of development, taking into consideration technology convergence and the emergence of new technologies. The IDI combines 11 ICT indicators cumulated into 3 composite sub-indexes related to ICT access, use and skills. The *access sub-index* captures ICT readiness, and includes five infrastructure and access indicators (fixed-telephony, mobile telephony, international Internet bandwidth, households with computers, and households with Internet). The *use sub-index* captures ICT intensity, and includes three ICT intensity and usage indicators (Internet users, fixed (wired)-broadband, and mobile broadband). The *skills sub-index* captures ICT capability or skills as indispensable input indicators. It includes three proxy indicators (adult literacy, gross secondary enrolment and gross tertiary enrolment), and therefore is given less weight in the computation of the IDI compared with the other two sub-indices.
Digital Access Index (DAI)	It refers to the difference among nations in the ability of accessing global information infrastructures, difference between those who have access to computers and the Internet and those who do not; it measures the overall ability of individuals in a country to access and use; is built on eight variables organized into five categories: Infrastructure (number of fixed and mobile subscribers), Affordability (internet access price as percentage of the Gross National Income per capita), Knowledge (adult literacy and school enrolment level), Quality (international bandwidth per capita and broadband subscribers) and Usage (internet users
ICT Diffusion index (ICTDI)	ICT Development Indices evolved into the ICT Diffusion Index (1990-2007), but was transformed in the ICT Opportunity Index.
	United Nations Conference on Trade and Development - UNCTAD's *Information Economy Report* (2005)

Source*:* ITU Measuring Information Society (2011), Dolnicar et al. (2004), World Economic Forum (2012), Howard, et al. (2007)

What one may notice is the abundance of data involved in assessing such a complex phenomenon, along with the evidence that many of the indicators may be highly statistical correlated as the cover in non accurate manner aspects of the same reality.

As an example of composite index, we will address the Networked Readiness Index (NRI) with the 2012 scores (given in the last edition of The Global Information Technology Report 2012 by World Economic Forum) – table 2.

Table 2. The components of Networked Readiness Index 2012

Subindex	**Description**
Environment subindex, 1-7 (best) -	The environment subindex gauges the friendliness of a country's market and regulatory framework to support high levels of ICT uptake and the development of entrepreneurship and innovation prone conditions for maximizing the potential impacts of ICT in boosting competitiveness and wellbeing. It includes a total of eighteen variables distributed into two pillars.
Readiness subindex, 1-7 (best)	The readiness subindex measures the degree of preparation of a society to make good use of an affordable ICT infrastructure and digital content, with a total of twelve variables.
Usage subindex, 1-7 (best)	The usage subindex assesses the individual efforts of the main social agents, i.e. individuals, business and governments, to increase their capacity to use ICT, as well as their actual use in their day-to day activities with other agents. It includes fifteen variables.
Impact subindex, 1-7 (best)	The impact subindex gauges the broad economic and social impacts accruing from ICT to boost competitiveness and wellbeing and that reflect the transformations towards an ICT and technology savvy economy and society. It includes a total of eight variables.

*Source***:** World Economic Forum (2012), The Global Information Technology Report (2012); Dataset Networked Readiness Index

In the next section, along with some general information on average values on the countries sample there will be considered four subject countries: Romania (as the main subject of interest), Bulgaria (sharing along the same trajectory in the last 5 years as Romania in their quality of the newest European states members, and also, being close in terms of geography), Sweden (as one of the permanent leaders in the ICT aspects in various hierarchies and top rankings) and Iceland (for the particular reason , that reports in 2010 the highest Internet penetration rate in terms of number of Internet users per 100 people – the World Development Indicators).

It may be seen from table 3, the poor positions of Romania and Bulgaria (with scores next to the middle of the score range) and the high values for Sweden and Iceland for the overall NRI score – figure 1. A deeper image on the country's performance is possible from figure 2 representing the general characterization of the distribution of the NRI scores reported by the 2012 edition. The graph allow some conclusive statements about each country performance as compared to the rest of the sample (in total, 142 countries): Sweden is placed on the best position with a percentile of 100% on the performance curve: Iceland reports a higher performance against 90% of the sample, Romania with the 67 rank and 53.19% percent of the curve and Bulgaria occupies the 70^{th} positions and placed above 51.00% of the countries.

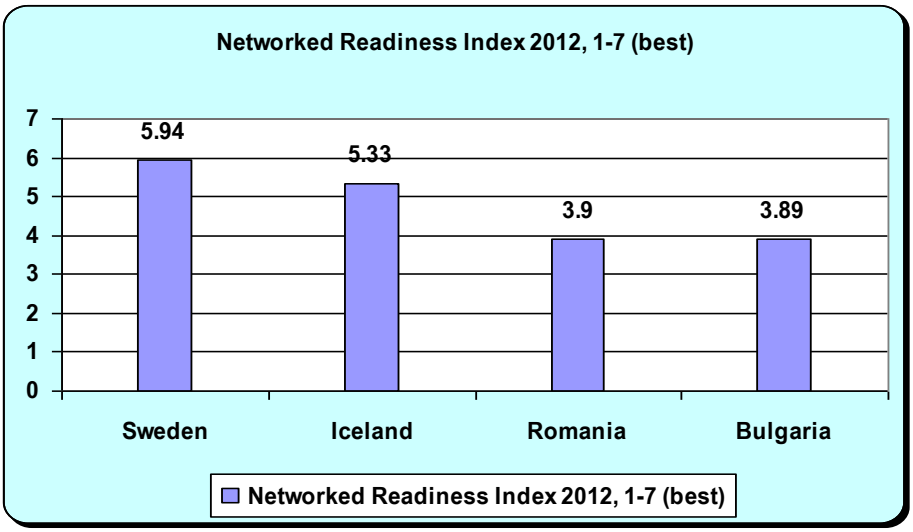

Figure 1. The Networked Readiness Index (NRI) score for the selected countries
Source*:* authors

Table 3. The country data on NRI for the selected countries

	Networked Readiness Index 2012		Environment subindex, 1-7 (best)		Readiness subindex, 1-7 (best)		Usage subindex, 1-7 (best)		Impact subindex, 1-7 (best)	
Entity	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**	**Rank**	**Value**
Sweden	1	5.94	3	5.51	3	6.44	1	5.92	2	5.09
Iceland	15	5.33	16	5.02	1	6.52	19	5.11	23	4.67
Romania	67	3.9	83	3.69	42	5.19	68	3.54	60	3.59
Bulgaria	70	3.89	73	3.78	73	4.65	70	3.5	90	3.21

Source: World Economic Forum (2012), The Global Information Technology Report (2012); Dataset Networked Readiness Index

The subcomponents of the index – the environment, readiness, usage and impact subindexes are also given for the selected countries, with the same pattern – figure 3.

The information provided by the NRI scores could be completed when other data regarding the overall macroeconomic and societal framework is considered – in the table 4, some other composite indexes are referred.

To deepen the analysis, a linear regression was performed between the set of the 142 scores of NRI and the values for the GGI. HDI and GDP per capita, respectively – table 5. All regressions reveal reasonable coefficients of determination; among them, the largest value for the slope coefficient is reached for the NRI=f(GDP) relation which indicates (not surprisingly) the strong determination of the population wealth on reducing the digital divide.

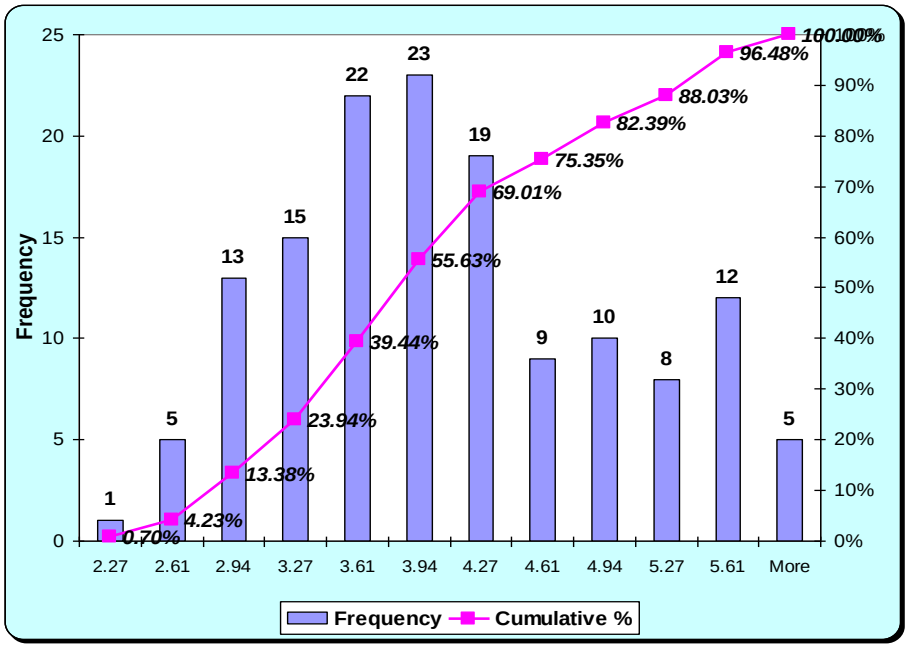

Figure 2. The histogram and the cumulative distribution for the NRI 2012 scores

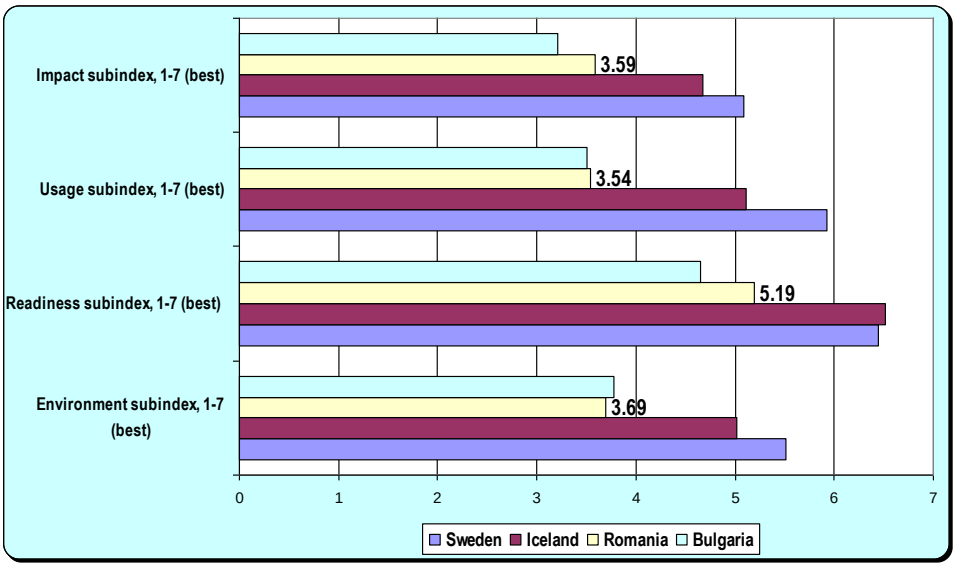

Figure 3. The Networked Readiness Index (NRI) 2012 scores for selected countries (the figures in graph correspond for Romania)

Source: Author compilation based on data from World Economic Forum (2012), The Global Information Technology Report (2012); Dataset Networked Readiness Index

Table 4. The value for the general indexes for the selected countries

Entity	Competitiveness Index (CGI) 2011-2012		Human Development Indicator (HDI) 2011, 0–1 (best)	Gross domestic product per capita - GDP per capita (US$)
	Rank	Value	Value	Value
Sweden	3	5.61	0.9	49,183.02
Iceland	30	4.75	0.9	39,025.70
Romania	77	4.08	0.78	7,542.25
Bulgaria	74	4.16	0.77	6356.12

***Source*:** GCI - World Economic Forum, The Global Competitiveness Report 2011-2012; HDI - United Nations Development Programme, The Human Development Report 2011; GDP - International Monetary Fund, World Economic Outlook Database (September 2011 update)

Table 5. Other composite indicators concerning general framework

Global Competitiveness Index 2011-2012, 1-7 (best)	$NRI = 1.41 + 1.28 \cdot GDI$	$R^2 = 0.887$
UNDP Human Development Indicator 2011	$NRI = 0.82 + 4.52 \cdot HDI$	$R^2 = 0.772$
Gross domestic product per capita - GDP per capita (US$)	$NRI = 3.43 + 0.00 \cdot GDP$	$R^2 = 0.613$

***Source*:** authors

The statistical view based on the WDI indicator – Internet users per 100 people

As the Penetration levels of mobile cellular subscriptions, Internet users and personal computers are some of the most common measures used, in the following section the number of Internet users is used for analysis. Generally, at international level, the most frequently used indicator of the digital divide is the number of access lines per 100 inhabitants. It is the leading indicator for the level of universal service in telecommunications and a fundamental measure of the international digital divide. It is reported covering a long period of time by World Development Indicators (WDI).

In the following sections, the indicator under analysis is the reported by the World Development Indicators (WDI) database; is named *Internet users per 100 people* and describes the number of Internet users are people with access to the worldwide network. There are several organizations that report the data: International Telecommunication Union, World Telecommunication/ICT Development Report and database, and even some World Bank estimates are given. The whole sample consists of a variable number of observations for the interval 1990-2010 (the maximum number of non zero values is 214, in 2010 there are 187 values).

The following graph represents the general evolution of the number of Internet users per 100 people for the selected countries: Romania (abbreviation ROU), Bulgaria (BGR), Sweden (SWE) and Iceland (ISL) – figure 4.

In table 7, the same information is given in terms of percentile, also pointing out the different pattern of growth in the indicators for Romania and Bulgaria, on one hand and the Sweden and Iceland on the other.

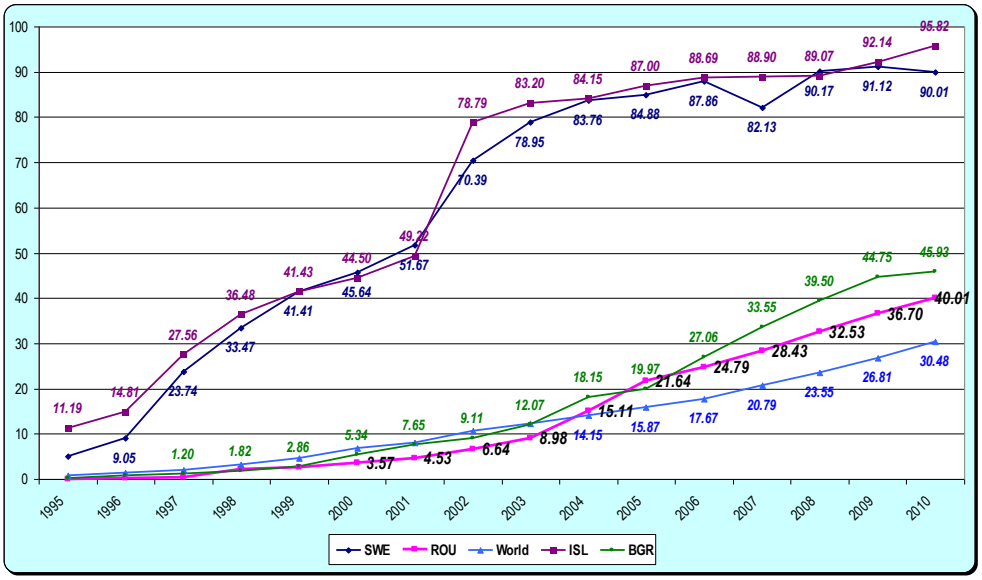

Figure 3. The evolution of Internet users per 100 people in interval 1995-2010
Source: Author compilation based on data from
http://data.worldbank.org/indicator/IT.NET.USER.P2

Table 6. The actual data for the countries under analysis

	1995	2000	2005	2010
World	0.7876	6.7785	15.8688	15.8688
Bulgaria	0.1190	5.3350	19.9680	45.9252
Iceland	11.1940	44.5038	87.0026	95.8195
Romania	0.0750	3.5733	21.6365	40.0078
Sweden	5.0957	45.6421	84.8799	90.0055

Source: Author compilation based on data from
http://data.worldbank.org/indicator/IT.NET.USER.P2

Table 7. The percentages in the performance profile

	1995	2000	2005	2010
Bulgaria	71.10%	66.00%	64.10%	72.50%
Iceland	99.50%	97.20%	100.00%	100.00%
Romania	67.40%	60.40%	67.90%	66.00%
Sweden	97.20%	97.60%	99.50%	98.10%

Source: Author compilation based on data from
http://data.worldbank.org/indicator/IT.NET.USER.P2

Based on the computations from table 8, the 5 number system is used to build the box plot graphs for the years under scrutiny - 1995, 2000, 2005 and 2010. It starts from a very narrow range of values corresponding to 1995 year – in a representation that is very poorly in pointing out the values for first quartile, median and upper quartile as indicators that signal the variability of the individual country performance as compared to the median – figure 6.

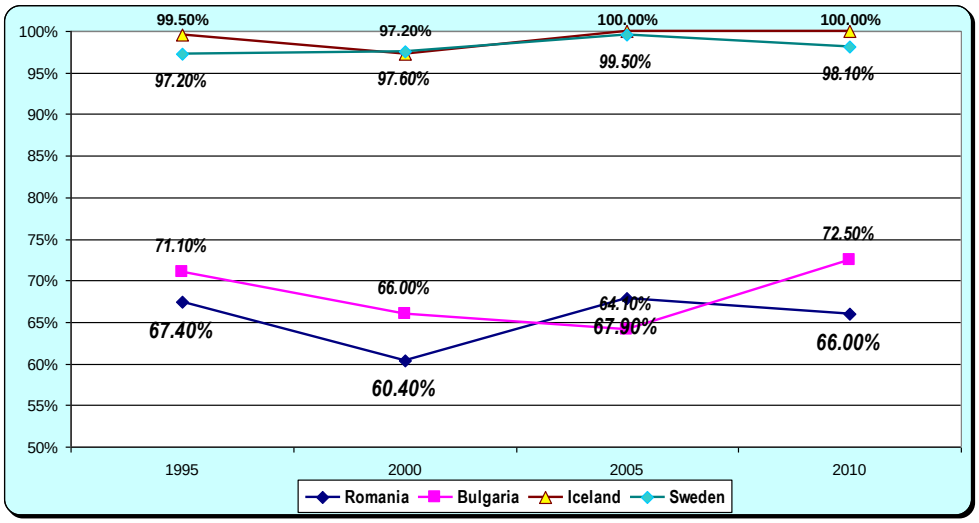

Figure 4. The performance profile for the selected countries in 1995-2010
Source*:* authors

Table 8. The descriptive statistics for the series of values – period 1995-2010

Indicator	1995	2000	2005	2010
Mean	0,61	7,63	19,04	30,02
SD	1,74	12,40	22,69	28,69
Min	0,00	0,00	0,00	0,00
Q1	0,00	0,18	1,65	3,89
Median	0,00	1,79	8,34	21,99
Q3	0,20	7,84	30,08	50,63
Max	13,90	51,13	87,00	95,82

Source: authors

For all years, the minimum values is zero (case that points out one of the shortages in using the quantile indicators for assessing the disparity among countries in the sample – most of the time, the zero value signals missing data); the maximum values grow significantly, the information about the rhythms of growth may be supplied by the regression method – table 9 in which the equations used are given, after best fitting the curves of evolution in the period 1995-2010.

As the literature of the DD domain suggests, the adoption of new technologies tends to follow a diffusion curve with three periods: early adoption, take-off period and maturity phase (Selhofer and Hüsing, 2001; Tiene, 2002, Hüsing and Hannes, 2003).

It may be seen that the Romania and Bulgaria, altogether with the "world" entity still can be associated to a linear type pattern; meanwhile the more developed countries (i.e. Sweden and Iceland) rely on a non-linear stage of growth.

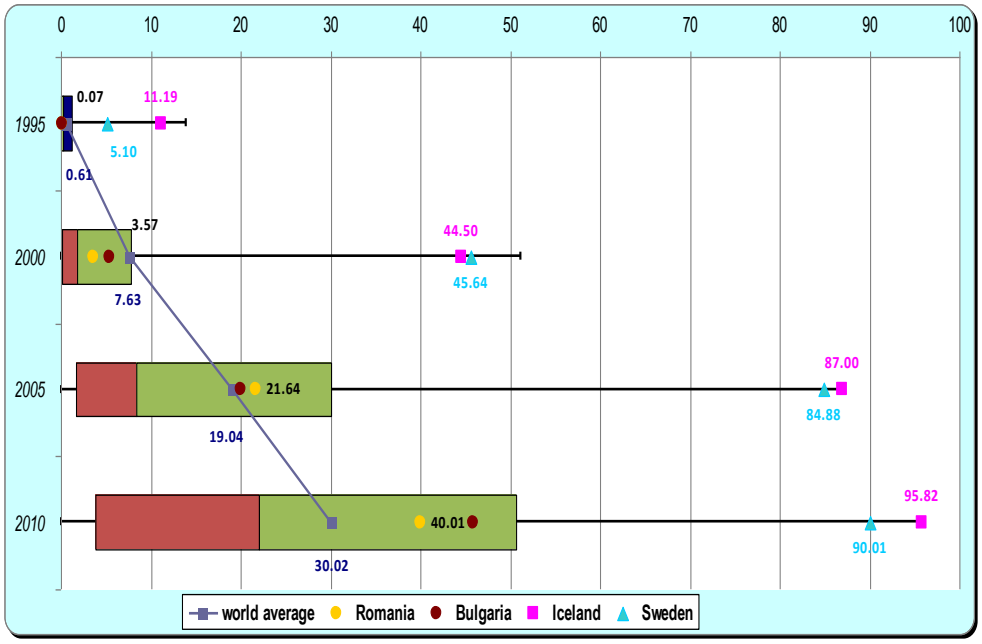

Figure 5. The box plot graphs for the series of Internet user per 100 pers. in 1995, 2000, 2005 and 2010
Source: authors

Table 9. The regression based on best curve fitting model

Unit/Country	Equation	R squared
World	$y_{world} = 1.9528 \cdot x - 4.1505$	$R_w^2 = 0.9714$
Bulgaria	$y_{BU} = 3.2992 \cdot x - 11.182$	$R_{BU}^2 = 0.9164$
Iceland	$y_{IS} = 36.306 \cdot \ln x - 6.2898$	$R_{IS}^2 = 0.9069$
Romania	$y_{RO} = 2.8547 \cdot x - 9.9794$	$R_{RO}^2 = 0.9144$
Sweden	$y_{SW} = 37.306 \cdot \ln x - 11.034$	$R_{SW}^2 = 0.9353$

Source: authors

The distance measurement indicators show the disparity or the gap among various units in the country sample, property that make them useful in assessing the digital divide (Lechman, 2010). Firstly, all data are standardized, in order to overpass problems related to measurement units, range of data etc. then, the data values are standardized by using the z-scores:

$$Z = \frac{X_c - X_0}{SD} \text{ or } Z = \frac{Xc - \overline{X}}{SD} \quad (2).$$

Where:

X_c is the current value of the indicator, X_b is the standard value of the indicator (or, alternatively the $\overline{x}$ mean is used), and *SD* is the standard deviation of scores in the population.

Once the data is standardized (for example with equation 2), different distance matrixes can be constructed: Euclidean, Manhattan, Chebyshev or Minkowski distance (equations 3-6). The computations are based on the following distance measures:

Euclidean distance: $$d_E = \sqrt{\sum_{k=1}^{p} (x^i{}_k - \overline{x}_k)^2} \quad (3)$$

Manhattan distance: $$d_M = \sum_{k=1}^{p} \left| x^i{}_k - \overline{x}_k \right| \quad (4)$$

Chebyshew distance: $$d_C = \max_{k=1,p} \left| x^i{}_k - \overline{x}_k \right| \quad (5)$$

Minkovski distance: $$d_{MI} = \left(\sum_{k=1}^{p} (x^i{}_k - \overline{x}_k)^m \right)^{\frac{1}{m}} \quad (6)$$

Where: x^i_k represent the indicator value for the country i in the k year (with $k=1,\ldots,p$); the comparison is made according to the "world values" of the indicator $\overline{x}_k$ (as given by the database) – see table 10 or by the computed mean of the reported values. In the analysis below this selected reference, the base is the "World" unit computed for the whole sample.
In the following section, three different proxies of "gaps" among selected countries are estimated.

Table 10. The distance values using as base the value for "world"

	Euclidean distance or Minkovski distance (k=2)	**Manhattan distance**	**Minkovski distance (k=1)**	**Minkovski distance (k=3)**
Bulgaria	1.1361	1.7284	0.7280	1.0420
Iceland	7.9082	14.9383	14.9383	6.7312
Romania	1.0033	1.7631	0.4279	0.8271
Sweden	5.6453	11.2331	11.2331	4.5351

Source: authors

The relative "position" of a given economy in comparison to the world value (this being the standard value for benchmarking) High values indicate great inequalities. The higher value of a specific metric, the greater distance or the larger the disparity in the number of internet users is observed between the given economy and the standard/benchmarking value. Iceland register the most remote position 9regardless the formula) situation that is explained by the having the maximum value for internet numbers per 100 persons (in 2010).

CONCLUSIONS

The digital divide – a phenomenon that raises the interest of various actors on the socio-economic environment is watched and monitorized carefully. The final aim in measuring this aspect of digital divide is to reflect the differences among and within countries in terms of access to physical infrastructure, such as computers and the Internet or even conventional communication infrastructure, such as fixed telephone lines. It may be quantified in many ways according to the specific perception of the monitoring agent,; yet, the researchers and academia has searched to provide rigor in selecting the indicator base and insights for the official statistical offices.
The digital divide is usually measured in terms of people's access to ICTs and our analysis tacked the WDI indicator of Internet users pre 100 people. Among the traditional static measures of disparities (e.g., percentage difference, ratio, Gini coefficient, Theil index, coefficient of variation, etc.) we have dealt with absolute and relative growth ration, the z-score, the descriptive statistics to compare the Romanian economy to the rest of the countries included in the WDI data base.

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