Digital divide – inequalities in level of implementation of new information and telecommunication technologies. Cross country study.

Lechman Ewa

Faculty of Management and Economics, Gdansk University of Technology

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Ewa Lechman[1]

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Abstract:
In the paper presented, the author considers few aspects of the so-called "digital divide". It is easily noticeable worldwide, that new information and communication technologies (ICTs) "possess" a great ability to spread, at high pace, among countries from all around the world. At the same time, we can see that ICTs are being implemented at different pace in difference economies. Different pace of ICTs implementation generates significant inequalities in level of usage and application of these technologies in different countries.
The main purpose of the paper is to assess magnitude of existing digital divides among countries, which can partly explain existing inequalities in use and application of ICTs.
The author will apply relevant methodology – taken from basic taxonomy methodology – to measure the digital divides among economies.
All countries where necessary data is available and reliable will be included in the study.

Key words: *inequalities, digital divides, ICTs*
JEL code classification: *O11, O33*

Introduction

The digital divide is an economic phenomenon and it should be analysed as such. Although it employs considering the strictly technical side of ICTs, on the other hand it has strong economical implications. If understood in such a way, the analysis of the problem of uneven ICTs implementation cannot be limited to the pure technological side solely.

In today`s world we can observe fast development of new information and communication technologies (ICTs). At the same time, almost in each country, one of the main targets of economic policy targets is fast implementation of ICTs in wide range of fields. Despite lacking any quantitative proof that ICTs implementation, does have positive influence of economic growth, case studies from all around the world show that ICTs usage influence positively general welfare of society. If it so, fast implementation of ICTs becomes highly desirable action which requires fosters economic and social development.

However, ICTs implementation is highly uneven in different countries. There is no need to run highly sophisticated statistical analysis to see great inequalities among countries in ICTs adoption.

[1] Ewa Lechman, Ph.D.
Faculty of Management and Economics
Gdańsk University of Technology
ul. Traugutta 79
80-233 Gdańsk
Poland
e-mail: eda@zie.pg.gda.pl

The main purpose of the paper below, is to define the meaning of the term "digital divide", learn about possible measurement methods and – finally – to assess the magnitude of digital inequalities among countries. The analysis is run for all economies where necessary data was available. The majority of data applied come from United Nations and International Telecommunication Union statistics.

1. Digital divide – defining the problem

"Technologies" as such, are not value-neutral. Theirs adoption causes certain consequences, which are not always perceived positively. We can observe their increasing pervasiveness within both – economy and society. Powell (1999) stated that broad technology application can lead directly to the formation of wide parts of societies which are unable to participate fully – from cultural, social and economic perspective, possessing even right, in a given society. These "parts" of a society are disadvantaged in some kind. A question arises, whether technologies are the "cause" of increasing inequalities within and among societies (countries).
On the second hand, the speed at which modern technologies spread all over the world is seen as a kind of phenomena. For the last 2 decades, we can observe dynamic development and broad adoption of New Information and Communication Technologies (ICTs). These can be treated as tools of achieving certain development targets, but also they are understood as one of production sectors in national economy. Some perceive ICTs as good mean of an enabler to close divides between "information – rich" and "information – poor". However, ICTs do help people to acquire all sorts of information and knowledge at low cost, they also "create" a new form of divides (gaps) among and within societies. These divides are widely recognized as "digital divides" or "digital gaps".

When we start talking about digital divides and issues associated, first comes to our mind a fundamental question: how should the digital divide be defined and measured? In the first section of the paper, the author explains the and summarizes main findings considering digital divides defining. Further – in section 2, - the author concentrates on measurement aspects.
Today`s emergence of fully digital media, way of communication, way of data storage, made it possible and justifiable to discus problem of "digital divide" at national and international level. But when digital divide theory is discussed, we need to point out first, that its roots are closely related to the "knowledge gap" theory. In the theory there was suggested that there is a significant gap between different segment in societies which is caused by different access to knowledge and its acquisition. Tichenor[2] says that: "segments of the population with higher socio-economic status tend to acquire information at a faster rate than the lower status segments so that the gap in knowledge between these segments tends to increase rather than decrease"[3]. After his further studies we find out that there are many independent factors which contribute to knowledge acquiring and perception. In the studied case of digital divide, one could state that ICTs are one of these independent variables explaining level of knowledge in a society. Considering the facts mentioned above it is fully justified to say that "digital divide theory" has grown from "knowledge gap theory".

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[2] Tichenor, P., C.O`Lien and G. Donohue, (1970), *'Mass media flow and differential growth in knowledge'*, *Public Opinion Quarterly*, 34, http://poq.oxfordjournals.org/cgi/content/summary/34/2/159,, accessed: 10 Feb 2009

[3] *Ibidem in* Selhofer H., Husing T. (2002), *The Digital Divide Index – a measure of social inequalities in the adoption of ICTs,* http://www.empirica.com/publikationen/documents/Huesing_Selhofer_DDIX_2002.pdf' accessed on 6 May 2009

So far, a quite number of studies has been published to solve the rather complicated aspect of "digital divide" defining. The term "digital divide" is simultaneously used with the term "digital gap" – both terms are used in the same sense.
In Dewan and Riggins (2005) work we can read, that digital gap refers to "the separation between those who have access to digital information and communication technologies and those who do not"[4]. They also stress that a great magnitude of work considering digital gaps focus on its very narrow dimension, regarding only who has physical access to ICTs infrastructure. Consequently they write that there is an essential need to broaden digital divide perception by adding some analyzing ability to effective usage of ICTs among those who have physical access to ICTs infrastructure.

According to the early research work on digital gaps, we can underline that firstly, the problem was associated strictly with access to pure IT technology. But having in mind wide application and usage of different ICTs tools the definitions seems to be too narrow. The need of its widening is rather obvious. The simple understanding of the digital gap, and diving the societies into two parts – as those "have" and "have nots" is not fully justified. Mainly it is because ICTs implementation cannot – and is not – limited to pure technical side, but is encompasses a wide range of different action which requires ICTs usage. According to DiMaggio and Hargittai (2001), the digital gaps should be analysed in 5 dimensions: technical (meaning hardware, software and connectivity), autonomy (freedom to access and use), use patterns (purposes of Internet usage), skills (ability to use the Internet effectively) and finally social support networks (possibility to access experienced ICT users)[5].

In practice, when trying to assess the magnitude of the digital divide, we can distinguish the divides at three conceptual levels[6]: (1) at individual level – when we take into account those who are technologically, sociologically or economically disadvantaged, they may lack basic access to ICTs infrastructure and service (they often choose to make or not ICTs as an integral part of their everyday life); (2) at organizational level – when ICTs implementation is discussed from firms` perspective (some of them implement ICTs in order to not lag behind and gain competitive advantages); and (3) at global level – when individual countries are taken into consideration (some of them invest strongly in promoting broad ICTs adoption, while others are left behind technologically). Also a different distinction exists. We could distinguish two different levels of digital gaps. The first one, would refer only to the situation when someone has or does not have a physical access to ICTs equipment. In the second case, we would refer only to people, who having physical access to ICTs equipment, possess or do not possess proper skills to use ICTs effectively. Many say that the very term "digital divide" is a flip side of e-inclusion. When taking about e-exclusion we just mean the disadvantaged groups which do not have a direct, cheap and easy access to ICTs tools.
Whatever we would say, the very concept of digital divide (gaps) always refers to the uneven access and usage of new ICTs and it has its socio-economic consequences. Probably providing a mere access to new technologies will not be sufficient to

[4] Dewan S., Riggins F.J. (2005), The digital divide: current and future research directions, as forthcoming as the lead article in a special issue of the Journal of the Association for Information Systems
[5] Kauffman R.J., Techatassanasoontorn A.A. (2005), Is there a global Digital divide for digital wireless phone technologies?, Journal of the Association for Information Systems. Special Issue. Vol. 6, No. 12, Dec 2005, pp.338-382.
[6] Dewan S., Riggins F.J., opt. cit.

eliminate existing digital gaps, but it surely is prerequisite condition to stop widening the knowledge and technology divides.
We observe the fact, that ICTs penetrate more and more spheres of daily life. ICTs are commonly perceived as facilitators of someone's employability, social, political and economic participation, and access to public services which are technologically facilitated, education forms or simply – health care. ICTs gaps cause information asymmetric among countries, and as consequence it stops country's ability to develop.

2. How to measure the digital divide?

The question of measurement methodology always is a crucial one for drawing right conclusion from the proposed analysis. In the case we reconsider for analyzing, we should find a method to be able to capture the magnitude and changes in digital gaps among countries. As the phenomenon of digital divide is a complex issue, which can be perceived in different dimensions, the aspect of its formal measurement remains complicated. The digital divide itself in many aspects is a qualitative phenomenon which determines obvious difficulties is its capturing in numbers. To capture its multidimensionality we need a sensible and complex measure which would enable us to compare the magnitude of existing divides among countries. Whatever the measurement would be, the measures still remains relatively imprecise. That implies certain inconvenience, especially having in mind the complexity and the magnitude of multivariate interactions among digital gap's determinants.
One of the measures which can be easily adopted for usage to learn about the magnitude of digital gaps among countries, is a methodology based on principals of basic taxonomy. The methodology lets us to find out about the magnitude of the gap between two objects (regions, countries), characterized by a bundle indicators. For assessment of the gaps (divides) among countries, the so called distance matrices are applied. To estimate the distances (gaps) we need a certain set of data used for characterizing analyzed objects. All indicators used for the analysis should constitute a representative set of indicators, each referring to different aspect of economical and social life to make the study complete and reliable. After preliminary selection of indicators, all data are standardized, to escape different units' problems. The data are standardized according to formal equitation:

$$a = \frac{x - \mu}{\rho}$$

Where:

x - stands for raw score to be standardized
μ - stands for all scores in the population
σ - stands for standard deviation of scores in the population

Once the data is standardized, the distance matrixes can be constructed. In mathematics, a distance matrix is a matrix which describes the distances – taken pair wise – of set of points. It is a two-dimensional array, where the number of pairs of points is determined by a number of independent elements applied for the analysis.

In the analysis we take "distances" – popularly called "gaps" or "divides", which can be described as an issue expressing how far certain objects are located from a selected reference standard object. In the analysis below this selected reference, standard is the best performing country in the whole group.

There are three most popular ways to calculate the gaps (divides) among objects. One can use alternatively Euclidean, Manhattan or Chebyshev distance. The Euclidean distance – also known as Euclidean metric, is a simple "distance"

between two points described one or more characteristics. The Euclidean distance between points A = (x_1, x_2 ……x_n) and B = (y_1, y_2,…….. y_n) in Euclidean n-space is formally defined as:

$$\text{Euclidean metric} = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} = \sqrt{(x_i - y_i)^2 + (x_i - y_i)^2 \ .....+(x_n - y_n)^2}$$

The second mentioned, Manhattan metric is also called as "city block distance" or "Manhattan length". In that case, the Euclidean geometry is replaced by a metric where distance between two points is calculated as a sum of the differences of their coordinates – usually expressed in absolute terms. Let us assume to have two points, point A and B, with their coordinates (x_1,y_1) and (x_2,y_2) respectively. In such case, the taxicab distance is calculated as following:

$$\text{Manhattan distance} = |x_1 - x_2| + |y_1 - y_2|$$

In addition, the last one, metric called Chebyshev distance (or Tchebyshev distance, chessboard distance) is a metric defined on a vector space where distances between two vectors is the greatest of their differences along coordinate dimension. Let us assume to have two points, point A and B, with their coordinates (x_1,y_1) and (x_2,y_2) respectively. The Chebyshev distance is explained in the following way:

$$\text{Chebyshev distance} = \max\left(|x_2 - x_1|, |y_2 - y_1|\right)$$

In the following section, all three different proxies of "gaps" among countries can be estimated. As result of calculation, a distance matrix will explain relative backwardness of each country in relation to any other included in the analysis. Each number (no units are applied) in the matrix will explain the relative "position" of a given economy in comparison to the others.

Presented methodology has its limitations, which is obvious. It can hide the true status of digital divides among countries, as not all indicators are involved in the analysis. As root data, the author applies two indexes, which are compound measures. These are ICT – Development Index (IDI), developed by International Telecommunication Union, and Networked Readiness Index (NRI), developed by World Economic Forum. IDI and NRI are complex indices where each one captures in numbers issues, which cannot be precisely calculated. They are only proxies, which help to understand the level of implementation of ICTs in different spheres of life. However imperfect they are, they enable to make international comparisons in time and space.

3. Comparing digital divides among countries – statistical analysis.

In modern economy we can observe wide and rapid growth of Internet use in – both – high and low income countries and whatever would be. No one can deny that never before, any innovation had such 'ability' to spread so fast all over the world. As we can conclude from different research, the diffusion of new information and communication technologies are strongly dependent on few variables. For example Robinson and Crenshaw (2002) stress that education, school enrolment have great impact on ICTs diffusion. According to Hargittai (1999), Kraemer et al. (2002) or Tellis et al. (2003), the Internet diffusion in a country is strongly related to the GDP per capita and a general wealth of a country. There are also some hypothesis that

Internet diffusion is dependent on infrastructure penetration, relative costs of ICTs goods and services. No matter what is the cause, the existence of digital divide among countries is a fact which cannot be denied. Intuitively we can conclude that the gaps are wide across countries, but actually is should be studied more carefully.
In the first section of this paragraph, the author will run an analysis to compare inequalities in ICTs implementation and adoption at rather macro level – the differences among continents will be compared. For each continent, the Gini coefficient is calculated to express in a simply way digital / technological inequalities among them. All data applied for the analysis are derived from International Telecommunication Union databases, and are mainly for period 2000 – 2007. All calculations are author's own work.
No one can deny that the Internet and other ICTs tools spread all over the world is massive. At the same time, it easily observed that the speed at which the ICTs is adopted in different world regions is highly uneven.
As pre-analysis, the author presents two tables (Table 1, and Table 2), where certain data for each continent are collected. The main purpose of the analysis is to identify growth rates of Internet usage in period 2000-2007. Number of Internet subscribers per 100 inhabitants and number of Internet users per 100 inhabitants are considered. Also the total subscribes and users growth rates are calculated.

Table 1. Changes in the Internet usage. Period 2000-2007.

	Subscribers per 100 inhab.	*Users per 100 inhab.*	*Subscribers per 100 inhab.*	*Users per 100 inhab.*	*Subscribers growth rate(total)*	*Users growth rate(total)*
	2000	***2000***	***2007***	***2007***	***2000-2007***	***2000-2007***
Africa	0.16	0.55	1.25	5.48	863 %	1 067 %
Americas	6.94	18.79	10.92	43.23	72 %	150 %
Asia	1.37	3.08	6.56	14.43	418 %	421 %
Europe[7]	8.12	14.07	20.60	43.65	190 %	218 %
Oceania[8]	14.60	35.58	31.68	52.36	92 %	62 %
World	2.88	6.51	8.29	20.79	219 %	253 %

Source: own estimates using data from ITU, 2009

As we can see from the Table 1, there exist huge disparities among continents when comparing the widespread of the Internet. Although there is a significant progress in implementing ICTs in each continent, it is still clearly visible that great differences exist. Concluding from the level of total subscribers and users growth rate, we can see that the progress is huge when considering Africa and Asia. In Americas, the growth rates are relatively low, but still high. In Table 2, just to have a general overview, the author shows total numbers of Internet users and Internet subscribers in certain continents. Additionally, shares of particulars continents in global Internet users and subscribers are calculated, to have an idea about the magnitude of divide among different world regions.

[7] Including Russia.
[8] Including Australia and New Zealand.

Table 2. Shares of global Internet subscribers and users in total values of continents. Period 2000-2007.

	Subscribers (in thousands)	*Users (in thousands)*	*Subscribers (in thousands)*	*Users (in thousands)*	*Share of global Internet subscribers*	*Share of global Interner users*	*Share of global Internet subscribers*	*Share of global Interner users*
	2000	**2000**	**2007**	**2007**	**2000**	**2000**	**2007**	**2007**
Africa	1 151	4486	11 091	52 348	0,68%	1,14%	2,08%	3,76%
Americas	55 579	157221	96 025	393 014	33,30%	39,95%	18,02%	28,29 %
Asia	48 449	110156	251 111	573 766	29,03%	27,99%	47,12%	41,30 %
Europe[9]	57 213	110647	166 012	352 143	34,28%	28,12%	31,15%	25,35 %
Oceania[10]	4 476	10939	8 623	17 746	2,68%	2,78%	1,61%	1,27%
World	166 868	393451	532 862	1389019				

Source: own estimates using data from ITU, 2009

In the time 2000-2007, shares of certain continents in total number of Internet subscribers and users, have changed significantly. Considering data of total Internet subscribers, we clearly see that the share of both Americas in total world share has fallen greatly. It does not proof, that in Americas there was no increase in Internet subscribers. It rather proofs, that the speed at which Internet is adopted in Americas was relatively slow. In year 2000, the share of given variable in total world`s was close to even – among Americas, Europe and Asia. In year 2007, the situation has changed slightly – now Asia poses the greatest share of Internet subscribers in the world. It proofs an extraordinary progress that was made in Asian countries in these aspects. Also in 2007, the share of Americas in total Internet subscribers has decreased up to 18,02%, which changed the position of the continent significantly. Shares of Africa and Oceania, stay still at relatively very low level. Considering that fact, that in Africa in period 2000-2007 the growth rates of total subscribers was at 863% (see numbers in Table 1), we can conclude that the absolute level of Internet implementation in the continent is still incredibly low. Numbers in Table 1 and 2, proof how intensively new ICTs are adopted within countries in the last 10 years. However, the implementation of them is universal, it does not mean that the inequalities among countries have diminished. One could expect that such digital divide shall decrease in its magnitude, not the opposite. Using the most common inequality measure – Gini coefficient, the author calculates inequalities in Internet adoption in different continents. We shall pose a question: is the gap between "haves" and "haves not" narrowing? In addition, if so, has is decreased significantly?

Below in Table 3, there are presented results of calculation of Gini coefficients for each continent separately (for years 2000 and 2007), taking into account number of Internet subscribers and number of Internet users.

[9] Including Russia.
[10] Including Australia and New Zealand.

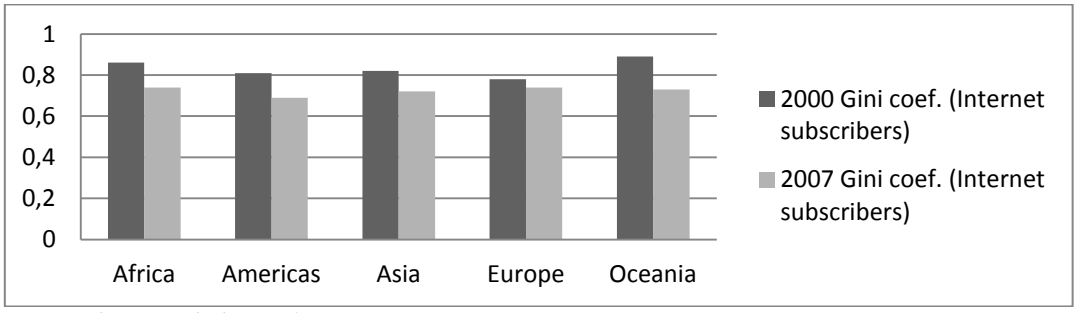
Table 3. Gini coefficients for continents, Internet subscribers and users. Years 2000 and 2007.

	2000		2007	
	Gini coef. (Internet subscribers)	**Gini coef. (Internet users)**	**Gini coef. (Internet subscribers)**	**Gini coef. (Internet users)**
Africa	0,86	0,70	0,74	0,64
Americas	0,81	0,72	0,69	0,74
Asia	0,82	0,74	0,72	0,64
Europe[11]	0,78	0,73	0,74	0,78
Oceania[12]	0,89	0,64	0,73	0,60

Source: own calculation using data from ITU 2009

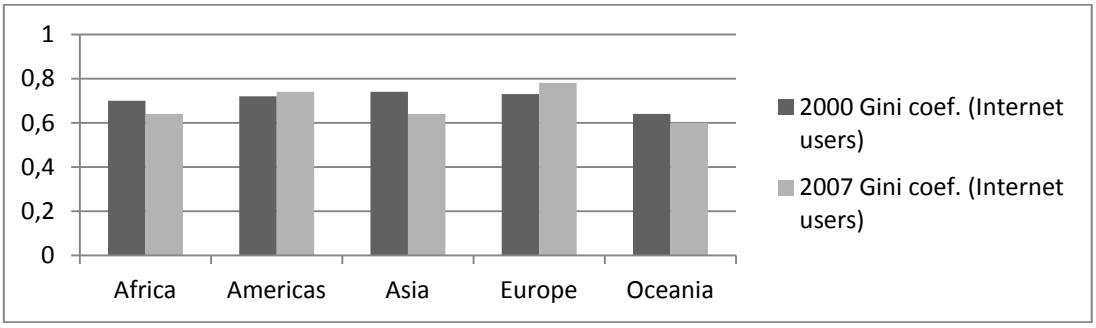
As we can clearly see in each case coefficients are high, despite slight decrease in 2007. These differences are huge and proof existence of great digital divides among nations. In each continent, the Gini coefficients have fallen – except the ones for Internet users in Europe and Americas. In graphs 1 and 2 (below), it is easily noticeable that inequalities among countries when Internet use and adoption is considered, it hardly changed.

Graph 1. Gini coefficients. Internet subscribers. Years 2000 and 2007.



Source: author`s elaboration.

Graph 2. Gini coefficients for Internet users. Years 2000 and 2007.



Source: author`s elaboration.

In the final section, the author assesses the magnitude of digital gaps among countries, using selected methodology. All countries where necessary data was available and reliable are included in the analysis. For technical reasons the author

[11] Including Russia.
[12] Including Australia and New Zealand.

had to exclude selected countries from the analysis – mainly due to lack of full data spectrum.
For calculating the digital divides among countries, the author – as already was mentioned before – applies, two commonly recognized indices: ICT – Development Index (IDI) and Networked Readiness Index (NRI). The indices were selected as proxies of measure showing level of ICTs adoption in economies.
IDI data are derived from the report "Measuring Information Society 2009. The ICT Development Index"[13] and "Measuring the Information Society 2010"[14], both published by ITU. The NRI data come from "The Global Information Technology Report 2001-2002"[15] "The Global Information Technology Report 2008-2009"[16]. All data cover period from year 2002 till 2009.
Data for IDI are presented for years 2002 and 2008 (the last available statistics), to capture changes in 7-year period. The data are available for 151 countries. Data for NRI are presented for years 2001-2002 and 2008-2009. The data are available for 75 countries.
In the Annex (see corresponding table at the end of the paper), the author puts all data applied for the analysis.
In the first step, the author calculates three kinds of metrics – the Euclidean, Chebyshev and Manhattan. All data are standardized before starting proper estimations.
In table 4, the author presents results of calculation digital divides in case of applying both ICTs measures – IDI and NRI. Calculations are made for years 2002 and 2009 separately.

Table 4. Digital divides among countries (calculated for ICT-Development Index and Networked Readiness Index).Year 2002. Euclidean, Manhattan and Chebyshev metrics. Single linkages.

	2002		
	Euclidean metric	**Manhattan metric**	**Chebyshev metric**
Sweden (reference country)	0,00	0,00	0,00
Netherlands	**0,14**	**0,20**	**0,12**
Korea	0,92	1,06	0,90
Denmark	**0,27**	**0,39**	**0,20**
Norway	**0,30**	**0,36**	**0,28**
Iceland	**0,51**	**0,70**	**0,43**
Switzerland	0,74	1,03	0,59
Finland	**0,49**	**0,62**	**0,46**
Canada	0,73	1,03	0,53
UK	0,70	0,99	0,54
United States	**0,63**	**0,85**	**0,55**
Hong Kong	0,85	1,19	0,66
Australia	0,90	1,26	0,71
Germany	0,97	1,37	0,71
Singapore	0,89	1,14	0,85
Japan	1,24	1,76	0,90
New Zeland	1,02	1,41	0,87
Austria	1,07	1,42	0,98
Slovenia	1,88	2,62	1,53
Italy	1,56	2,20	1,14
France	1,57	2,21	1,16

[13] Measuring the Information Society 2009. ICT Development Index, Information Telecommunication Union, Geneva 2009.
[14] Measuring the Information Society 2010", Information Telecommunication Union, Geneva 2010.
[15] The Global Information Technology Report 2001-2002, World Economic Forum, Geneva, 2002.
[16] The Global Information Technology Report 2008-2009, World Economic Forum, Geneva, 2009.

Belgium	1,45	2,03	1,17
Ireland	1,46	2,05	1,17
Israel	1,56	2,18	1,26
Spain	1,77	2,50	1,35
Greece	2,20	3,10	1,64
Estonia	1,80	2,51	1,47
Portugal	1,93	2,71	1,51
Czech Rep	2,12	2,99	1,60
Slovakia	2,49	3,52	1,76
Hungary	2,41	3,40	1,78
Poland	2,69	3,80	1,92
Latvia	2,76	3,90	1,99
Lithuania	2,91	4,11	2,18
Argentina	2,72	3,83	2,07
Chile	2,77	3,90	2,14
Uruguay	2,94	4,15	2,18
Jamaica	3,36	4,74	2,48
Bulgaria	3,31	4,69	2,39
Malaysia	3,01	4,24	2,30
Russia	3,48	4,92	2,60
Brazil	3,13	4,41	2,43
Costa Rica	3,28	4,63	2,43
Trinidad&Tobago	3,34	4,71	2,46
Ukraine	3,67	5,18	2,72
Romania	3,64	5,15	2,67
Mauritius	3,44	4,87	2,50
Panama	3,44	4,87	2,52
Turkey	3,28	4,62	2,52
Mexico	3,36	4,74	2,55
Jordan	3,47	4,91	2,56
Colombia	3,66	5,17	2,68
Venezuela	3,57	5,04	2,68
Thailand	3,47	4,88	2,69
Peru	3,61	5,10	2,71
South Africa	3,42	4,79	2,73
Philippines	3,73	5,26	2,76
Bolivia	3,90	5,52	2,79
Paraguay	3,83	5,42	2,80
Dominican Rep	3,62	5,08	2,83
Ecuador	4,22	5,95	3,12
China	3,90	5,52	2,84
Egypt	3,91	5,51	2,94
Sri Lanka	3,97	5,60	2,98
El Salvador	3,88	5,46	2,99
Guatemala	4,15	5,86	3,09
Vietnam	4,56	6,45	3,35
Indonesia	4,02	5,66	3,13
Nicaragua	4,38	6,19	3,25
Honduras	4,54	6,42	3,29
Zimbabwe	4,46	6,29	3,30
India	4,17	5,82	3,37
Nigeria	5,03	7,12	3,68
Bangladesh	4,76	6,73	3,49

Source: own calculations.

In the Table 4, (above), the author presents results of own estimations of the magnitude of digital gaps existing among countries. For the analysis 74 countries were selected, as only for such number necessary set of data were applicable. In year 2002, the Swedish economy was selected as the reference standard object – as the one best performing in the group of counties. In that case, Sweden can be treated as an economy with relatively the highest level of implementation of ICTs

within society. Each sequent country is compared to Sweden therefore. The numbers in the Table 4 can be interpreted as the measure explaining the relative "distance" between Sweden and a given country. The distance metric shows the gap between two objects, giving an idea of how far two objects are located from each other. High values indicate great inequalities. The higher value of the metric the greater distance is observed between the given economy and Sweden. In year 2002, countries like: Netherlands (0,14), Denmark (0,27), Norway (0,30), Finland (0,49) or Iceland (0,51), could benefit from relatively highest level of ICTs` adoption, in comparison to Sweden. It proofs that within these societies ICTs tools are widely used and access to them is not limited, while relative costs of achieving certain ICTs equipment and services is low, which means that they can be purchased easily by a great part of society members. Not surprisingly the least developed countries – like Nigeria, Bangladesh, Honduras or Zimbabwe, are these where the level of ICTs adoption is relatively low. It does not proof that in such economies ICTs tools are not implemented at all. From many case studies we know, that usually the main target of the economic policies implemented there is broad application of ICTs in all spheres of life. However, as we can learn from ITU databases[17], the growth rate of ICTs usage and application are astonishing (compare Table 1 and 2), the absolute level of ICTs adoption in societies stays at low level.
In the following Table 5, the author has presented the analogous calculations, but applying data after 7-year break (for year 2009).

Table 5. Digital divides among countries (calculated for ICT-Development Index and Networked Readiness Index).Year 2009. Euclidean, Manhattan and Chebyshev metrics. Single linkages.

	2009		
	Euclidean metric	**Manhattan metric**	**Chebyshev metric**
Sweden (reference country)	0,00	0,00	0,00
Netherlands	**0,49**	**0,68**	**0,42**
Korea	**0,57**	**0,66**	**0,56**
Denmark	**0,17**	**0,18**	**0,17**
Norway	0,58	0,82	0,42
Iceland	**0,53**	**0,74**	**0,41**
Switzerland	**0,47**	**0,67**	**0,36**
Finland	0,58	0,82	0,45
Canada	0,90	1,25	0,73
UK	0,80	1,10	0,68
United States	0,73	0,90	0,71
Hong Kong	0,78	1,08	0,65
Australia	0,83	1,17	0,66
Germany	0,94	1,29	0,80
Singapore	**0,53**	**0,69**	**0,48**
Japan	0,87	1,17	0,78
New Zeland	1,11	1,52	0,96
Austria	0,96	1,35	0,74
Slovenia	1,75	2,38	1,52
Italy	2,21	2,93	2,01
France	1,07	1,50	0,80
Belgium	1,27	1,79	0,98
Ireland	1,21	1,69	0,97
Israel	1,36	1,93	1,03
Spain	1,82	2,46	1,61
Greece	2,41	3,19	2,21
Estonia	1,10	1,55	0,78
Portugal	1,83	2,57	1,45

[17] www.itu.int (see statistics)

Czech Rep	2,03	2,86	1,57
Slovakia	2,38	3,31	1,98
Hungary	2,22	3,06	1,87
Poland	2,81	3,82	2,45
Latvia	2,50	3,47	2,09
Lithuania	2,12	2,97	1,73
Argentina	3,29	4,58	2,71
Chile	2,68	3,79	1,97
Uruguay	3,04	4,28	2,39
Jamaica	3,18	4,49	2,32
Bulgaria	2,93	4,05	2,45
Malaysia	2,46	3,39	2,10
Russia	3,06	4,26	2,48
Brazil	3,15	4,45	2,28
Costa Rica	3,24	4,58	2,36
Trinidad&Tobago	3,38	4,77	2,60
Ukraine	3,18	4,49	2,35
Romania	2,80	3,92	2,24
Mauritius	3,19	4,50	2,38
Panama	3,29	4,65	2,40
Turkey	3,14	4,44	2,31
Mexico	3,45	4,88	2,48
Jordan	3,14	4,41	2,43
Colombia	3,27	4,62	2,36
Venezuela	3,70	5,19	2,94
Thailand	3,20	4,50	2,47
Peru	3,76	5,31	2,84
South Africa	3,45	4,85	2,73
Philippines	3,80	5,37	2,69
Bolivia	4,59	6,44	3,62
Paraguay	4,44	6,24	3,49
Dominican Rep	3,65	5,15	2,66
Ecuador	4,28	6,01	3,37
China	3,21	4,51	2,49
Egypt	3,73	5,27	2,77
Sri Lanka	3,78	5,33	2,88
El Salvador	3,82	5,40	2,82
Guatemala	3,89	5,50	2,87
Vietnam	3,57	5,04	2,59
Indonesia	3,94	5,56	2,90
Nicaragua	4,66	6,58	3,52
Honduras	4,10	5,79	2,91
Zimbabwe	5,27	7,43	4,02
India	3,94	5,46	3,29
Nigeria	4,40	6,20	3,34
Bangladesh	5,12	7,23	3,76

Source: own calculations.

In year 2009, the standard reference object is Sweden again, as an economy which performs best in the ICTs adoption and usage. The country is still the world leader in adoption of new information and communication technologies. Consequently each following country is compared to Sweden. As in 2002, if a country is relatively close to Sweden – it proofs that ICTs level of ICTs adoption and implementation there is close to the analogous scores in Sweden. In year 2009, countries closest to Sweden are: Denmark (0,17), Switzerland (0,47), Netherlands (0,49), Singapore (0,53) and Korea (0,57). Countries which were lagging behind in year 2002, are still in the last positions of the ranking.

To have a closer look at changes in positions of each economy in period 2002-2009, in comparison to Sweden, the author estimates the changes in Euclidean metrics values. Results of estimation are presented in Table 6 (below).

Table 6. Changes in the metrics values (reference country – Sweden). Time 2002-2009.

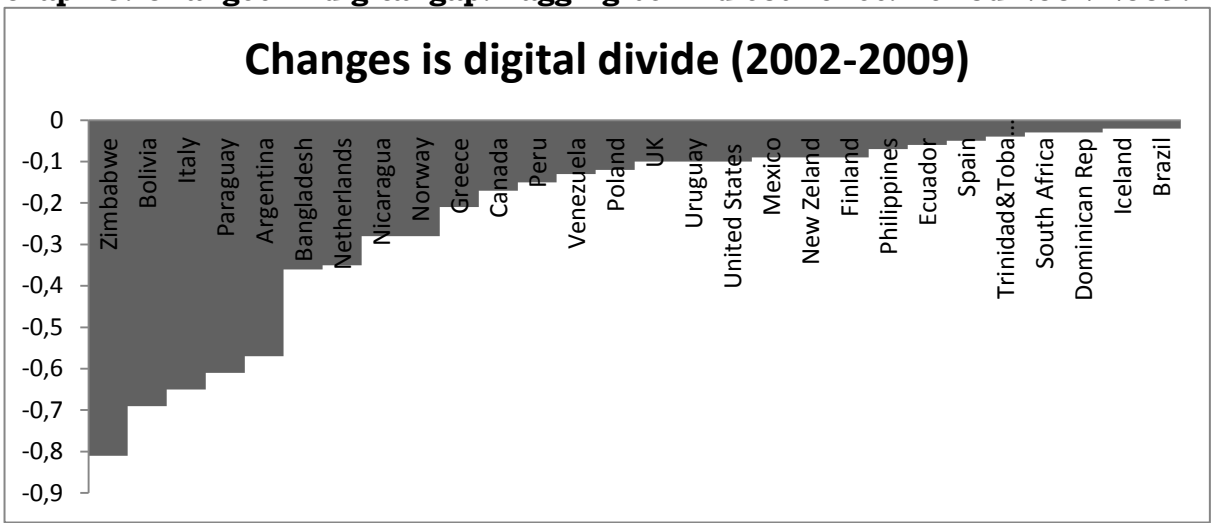
	2002	2009	Changes in metrics values (Euclidean metric 2002 – Euclidean metric 2009)
	Euclidean metric	Euclidean metric	
Zimbabwe	4,46	5,27	-0,81
Bolivia	3,9	4,59	-0,69
Italy	**1,56**	**2,21**	**-0,65**
Paraguay	3,83	4,44	-0,61
Argentina	2,72	3,29	-0,57
Bangladesh	4,76	5,12	-0,36
Netherlands	**0,14**	**0,49**	**-0,35**
Nicaragua	4,38	4,66	-0,28
Norway	**0,3**	**0,58**	**-0,28**
Greece	**2,2**	**2,41**	**-0,21**
Canada	0,73	0,9	-0,17
Peru	3,61	3,76	-0,15
Venezuela	3,57	3,7	-0,13
Poland	**2,69**	**2,81**	**-0,12**
UK	**0,7**	**0,8**	**-0,1**
Uruguay	2,94	3,04	-0,1
United States	0,63	0,73	-0,1
Mexico	3,36	3,45	-0,09
New Zeland	1,02	1,11	-0,09
Finland	**0,49**	**0,58**	**-0,09**
Philippines	3,73	3,8	-0,07
Ecuador	4,22	4,28	-0,06
Spain	**1,77**	**1,82**	**-0,05**
Trinidad&Tobago	3,34	3,38	-0,04
South Africa	3,42	3,45	-0,03
Dominican Rep	3,62	3,65	-0,03
Iceland	**0,51**	**0,53**	**-0,02**
Brazil	3,13	3,15	-0,02
Germany	0,97	0,94	0,03
Costa Rica	3,28	3,24	0,04
El Salvador	3,88	3,82	0,06
Hong Kong	0,85	0,78	0,07
Australia	0,9	0,83	0,07
Indonesia	4,02	3,94	0,08
Chile	2,77	2,68	0,09
Czech Rep	2,12	2,03	0,09
Portugal	1,93	1,83	0,1
Denmark	0,27	0,17	0,1
Austria	1,07	0,96	0,11
Slovakia	2,49	2,38	0,11
Slovenia	1,88	1,75	0,13
Turkey	3,28	3,14	0,14
Panama	3,44	3,29	0,15
Jamaica	3,36	3,18	0,18
Belgium	1,45	1,27	0,18
Egypt	3,91	3,73	0,18
Hungary	**2,41**	**2,22**	**0,19**
Sri Lanka	3,97	3,78	0,19
Israel	1,56	1,36	0,2
India	4,17	3,94	0,23
Ireland	**1,46**	**1,21**	**0,25**
Mauritius	3,44	3,19	0,25
Latvia	**2,76**	**2,5**	**0,26**

Guatemala	4,15	3,89	0,26
Switzerland	**0,74**	**0,47**	**0,27**
Thailand	3,47	3,2	0,27
Jordan	3,47	3,14	0,33
Korea	0,92	0,57	0,35
Singapore	0,89	0,53	0,36
Japan	1,24	0,87	0,37
Bulgaria	**3,31**	**2,93**	**0,38**
Colombia	3,66	3,27	0,39
Russia	**3,48**	**3,06**	**0,42**
Honduras	4,54	4,1	0,44
Ukraine	**3,67**	**3,18**	**0,49**
France	**1,57**	**1,07**	**0,5**
Malaysia	3,01	2,46	0,55
Nigeria	5,03	4,4	0,63
China	3,9	3,21	0,69
Estonia	**1,8**	**1,1**	**0,7**
Lithuania	**2,91**	**2,12**	**0,79**
Romania	**3,64**	**2,8**	**0,84**
Vietnam	4,56	3,57	0,99

Source: own estimations.

The negative score in the last column proofs that a country has relatively worsen its performance in ICTs adoption in period 2002-2009. The general (absolute) level of ICTs implementation has increased, however growth rates are too low, to converge fully with the leading economy (Sweden). In the graph below (Graph 3), there are presented economies which have increased the distance from Sweden in period 2002-2009. Main lagging behind countries, are these where the speed of ICTs implementation is relatively the lowest. The possibility of advancing still exists, but requires great efforts in terms of enhancing policies to provide greater accessibility to basic ICTs infrastructure and services.

Graph 3. Changes in digital gap. Lagging behind countries. Period 2002-2009.



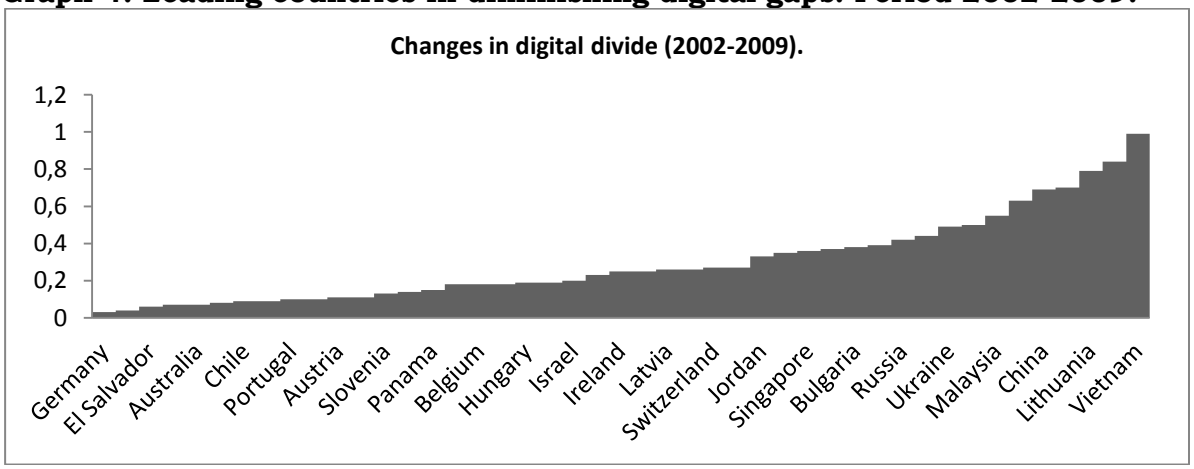
Source: own elaboration.

Countries like: Zimbabwe (-0,81), Bolivia (-0,69) Bangladesh (-0,36), they have greatly increased their distance from reference economy (Sweden). Their backwardness in terms of relative level of ICTs adoption has increased significantly. Rather surprising is the fact that countries like Italy, Netherlands, Norway, Greece or Canada have increased their distance from Sweden. They are classified as "marauder" countries, the so called "latecomers". Actually 12 out of 28 countries in

the "lagging behind" group are high income countries[18]. High income countries generally do not experience barriers to the adoption of information and communication technologies, like developing countries usually experience. It is not surprising that countries like Zimbabwe, Bolivia or Bangladesh have increased their distance from the Sweden. Obvious obstacles like for example: institutional barriers, lack of financial resources, low human capital and lack of capabilities are common for low income economies. In addition cultural issues are of great importance. It often happens that implementation of ICTs tools – even basic ones – requires a group of knowledgeable people to promote and enable diffusion of ICTs within society. Most of developing countries lack of such "professional groups" which constitutes main barrier that need to be overcome first. Another factor determining poor ICTs adoption, are weak institutions, especially undemocratic governments, which are concerned with free and uncontrolled flow of information from the outside world. Lack of financial funds for investing in telecommunication infrastructure disables ICTs to spread freely, which consequently limits providing education especially to socially and economically disadvantaged groups. All these are major impediments which considerably contribute to countries` backwardness in terms of level ICTs implementation.

Contrary, at the bottom of Table 6, we can find countries, which in period 2002-2009, have significantly decreased their distance from Sweden. The positive values in changes mean that a given country has caught up with the leaders in ICTs adoption. It proofs extraordinary relatively high growth rates of ICTs usage and implementation, but also an existing of "ICTs friendly" country policies which are aimed at high investing in information society creation and development. In the group of "leaders" in terms of diminishing digital gap, we can find: Vietnam (0,99), Romania (0,84), Lithuania (0,79), Estonia (0,70) and China (0,69). If we look further we can note countries like Honduras, Nigeria, Malaysia or Colombia, low income and suffering from permanent underdevelopment countries, which in the last few years experience extraordinary betterment of level of ICTs adoption. However, the growth rates for Internet adoption are relatively high; in absolute terms the level of ICTs implementation stays at low level. In countries like for example Vietnam, it means a great progress in creating telecommunication infrastructure and at a time creating great opportunities for each inhabitant. The Internet revolution that these economies undergo is widely recognized as a prerequisite condition to enter the path of socio-economic development.

Graph 4. Leading countries in diminishing digital gaps. Period 2002-2009.



Source: own elaboration.

[18] Formally classified as such by World Bank.

In case of countries which values are close to "zero" – but still positive, the digital gaps almost did not change, but relatively are a bit smaller. It proofs that in economies like Germany, El Salvador, Australia or Chile, the growth rates of ICTs implementation are close to be even. Countries like China, Singapore, Malaysia, Vietnam are these where ICTs adoption is wide and very dynamic. It creates certain gains and benefits for these economies, and also is a great opportunity to catch up with high developed countries.

4. Final conclusions

Should we worry about digital divides existing among countries? The study above has shown us that inequalities in adoption of new information and communication technologies are persistent and high. The issue of digital gap itself does not constitute a problem, but one must remember that on one hand – digital gap causes development inequalities, and – on the other had – it impedes or even disables entering the path of economic and social development. There we have a vicious circle of underdevelopment and technology lags. This circle must be broken to enable these countries to develop and use their resources effectively. However, poor nations should – in their own interest – make significant efforts to reduce existing within their societies as well as reduce the distance from high developed economies. Due to special features ICTs posses – like being cheap, or being able to spread at high speed, some network externalities which show up while using ICTs, digital divided could be reduced. But it is only possible when concrete actions are undertaken, "before the Internet gap between wealthy and poor countries becomes and insurmountable chasm, resulting in many of the negative consequences that arise from the uneven diffusion of industrial and network technologies in the world economy"[19].

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