Research Article

Examining the Global Digital Divide: A Cross-Country Analysis

Sona Mardikyan, Endam Ayçiçek Yıldız, Mehmet Derya Ordu and Burcu Şimşek

Department of Management Information Systems, Bogazici University, Istanbul, Turkey

Correspondence should be addressed to: Sona Mardikyan; mardikya@boun.edu.tr

Abstract

Despite the development of the information society and the widespread diffusion of information technology, the disparities between groups of countries in terms of accessing and using information and communication technologies (ICTs) are still valuable. This disparity is defined as the term of digital divide. Although there are several different views about measuring the digital divide, in this study, International Telecommunication Union's (ITU) ICT key indicators are used to measure the global digital divide. The cross-sectional data are collected for 145 countries in the world, for year 2011. One-way ANOVA and regression analysis are applied as statistical methods to analyze global digital divide. According to the results, variables related to development levels, income levels, Organization for Economic Co-operation and Development (OECD) membership and continental differences are highly associated with the digital divide.

Keywords: Digital Divide, Global Digital Divide, Information and Communication Technologies, Cross-Country Analysis

Introduction

The rapid development of information and communication technologies (ICTs) has fundamentally altered many aspects of life and societies all around the world. These developments affect the way of the communications, business transactions, daily routines and life styles. Now, e-mailing, web-surfing, blogs, social media tools, YouTube, internet news, online shopping, online services are indispensable components of life for many people. Today, in many countries e-learning, e-commerce, e-business, e-banking, e-finance, and e-tax implementations have developed and used frequently. Most of the developed and developing countries have prepared their national e-government and e-health platforms. The World Bank has determined many specific targets related to ICT. Furthermore, it has presented ICT as a way of the accelerating economic development and reducing the poverty.

_____

_____

In spite of continuous development of ICTs, members of a society do not have the same access level to ICTs. There is remarkable difference between individuals in terms of reaching and using the information. This difference is not only between individuals in society but also between groups, regions, countries and continents. Many countries try to implement new policies to achieve their technological goals and consequently to close the digital difference between citizens. At that point, the concept of digital divide comes into prominence. The digital divide is defined by Organization for Economic Co-operation and Development (OECD) 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 and to their use of the Internet for wide variety of activities" (OECD, 2001). Digital divide can be analyzed in two different scales: global and domestic. The former scale is about the analysis of the divide among different continents and countries while the later is about the gap between groups and regions of the same country. The main reason of the global digital divide is the difference of the social and economic inequalities between developed and developing countries.

In this study, instead of addressing the full set of issues related to the digital divide, International Telecommunication Union's (ITU) ICT key indicators are used to measure the gap between countries. The continuous independent variables of the study are selected as Human Development Index (HDI), Gross National Income per Capita (GNIpc), and Education Index of the countries. The study also aims to find whether other important categorizations such as being an OECD country, being a developed country, and having different income levels have effects on the digital divide.

Literature Review

There are various researches to measure the digital divide taking into consideration different data types, research methods, and data periods.

In the literature, various indicators are used to measure the digital divide. Techatassanasoontorn and Kauffman (2005) use wireless technology, Dewan et al., (2005) use IT penetration, Cuervo and Menendez (2006) use ICT-related indicators, Crenshaw and Robinson (2006) use Internet, Dewan et al., (2010) use PC and Internet, Banker et al., (2011) use digital trading platform, Talukdar and Gauri (2011) use Internet access and usage. Bagchi (2005) investigates the factors that contribute to the problem of digital divide in the global community with the value of an information technology index which is comprised of four IT adoption data (the Internet, PC, Cell phone and telephone). These analyses are carried out by cross-sectional and time-series methods and with a large set of variables that may affect the cross-country divide.

Dewan and Riggins (2005) highlighted current and potential future work on issues related to the digital divide at three levels of analysis: the individual level, the organizational level, and the global level. For each issue, they have identified a variety of research questions to stimulate more work in this area. Corrocher and Ordanini (2002) emphasized the multidimensional and complex nature of digital divide and pointed out the role played by political, institutional, and cultural cross-country differences to explain the gap. Doong and Ho (2012) collected secondary data of ICT relevant variables of 136 countries spanned five continents from 2000 to 2008. The methodology behind their framework involved data clustering and multi-dimensional data ranking. They showed that most countries had a convergent ICT development path during this period, and countries with different gross national income (GNI) levels have different ICT development paths. The goal of the research conducted by Pick and Azari (2008) is to analyze the influence of socioeconomic, governmental, and accessibility factors on

_____

_____

ICT usage, expenditure, and infrastructure in 71 developing and developed countries. For developed nations, technology factors are strongly associated with scientific publications, foreign direct investment, % of females in the labor force, and education variables. For developing countries, technology attributes are strongly associated with foreign direct investment, government prioritization of IT, and education variables. Chen and Wellman (2004) stated that the digital divide has occurred at the intersection of both international and within-country differences in socioeconomic, technological and linguistic factors. Billon et al., (2009) presented a cross-country study on the determinants of information and ICT diffusion. Canonical correlation analysis was employed to explain the differences ICT adoption. The results provide the ability to distinguish between different patterns of ICT adoption that can be explained primarily by variables associated with differences in development levels. Another study is concentrated on explaining the determinants of ICT diffusion (Kiiski and Pohjola, 2002). The main findings from empirical evidence show the close links between ICT diffusion disparities and economic development. Similar to other innovations, economic wealth is a prerequisite for ICT diffusion and a main determinant of digital divide. Zhao, et al., (2007), based on nine year cross-country data, identified that rule of law, educational systems, and industrialization are important factors to explain global Internet diffusion. According to Chinn and Fairlie (2007), economic and demographic factors are associated with the cross-country digital divide.

The study which is conducted by Çilan et al., (2009) analyzed whether a digital divide exists among European Union (EU) members, new members, and candidate countries. They also examined that the digital divide has a significant association with the process of becoming an EU member. MANOVA was applied to determine differences among the groups in terms of information society levels. According to the results of the study, there is a significant level of digital divide in the EU and a certain information society level currently is not associated with EU membership. Cruz-Jesus et al., (2012) analyzed digital divide within the European Union between the years of 2008 and 2010. According to this study, a digital gap exists within the European Union. The process of European integration and the economic wealth emerge are the explanatory factors for the divide. On the other hand, the educational attendance is not found to be an important factor. Labrianidis & Kalogeressis (2006) explored the main characteristics of the digital divide in Europe's rural enterprises and found that rural firms appear to be more or less digital in the most developed countries, while in the less developed countries adoption has been much slower. They also showed the characteristics of human capital are the most significant factors that influence the uptake of ICTs. Vicente and López (2008) analyzed Internet adoption in the new member states and candidate countries of the European Union. They stated that income, educational attainment and age are the main determinants of Internet use. Goldfarb and Prince (2008) found that high-income, educated people were more likely to have adopted the internet; however, low-income, less-educated people spend more time online.

The ICT Development Index (IDI)

International Telecommunication Union (ITU) has been established in 1865 and it is one of the most important organizations that work comprehensively and conduct researches on the topic of Global Digital Divide. ITU has been publishing a yearly comprehensive report which is titled as 'Measuring Information Society' since 2007 and in this report it is aimed to monitor information society developments worldwide using two authoritative benchmarking tools. One of these tools is the ICT Development Index (IDI) tool which ranks 155 countries' performance with regard to information and communication

_____

_____

technology infrastructure and uptake. According to the ITU report, one of the main objectives of the IDI is to measure the digital divide by illustrating the differences between countries with different levels of ICT development. The other tool is the ICT Price Basket (IPB) which is a unique metric that tracks and compares the cost and affordability of ICT services in more than 160 countries globally.

The IDI is a composite index combining 11 indicators into one benchmark measure that serves to monitor and compare developments in information and communication technology between countries. Each indicator has its own reference value and weight to be used in the calculation of sub-indices (ICT access, ICT use, and ICT skills) of the IDI. ITU selected these indicators based on certain criteria such as relevance for the index objectives, data availability and the results of various statistical analyses.

The indicators under each sub-index are as follows:

ICT Access

- Fixed telephone lines per 100 inhabitants
- Mobile-cellular telephone subscriptions per 100 inhabitants
- International Internet bandwidth (bit/s) per Internet user

- Percentage of households with a computer
- Percentage of households with Internet access
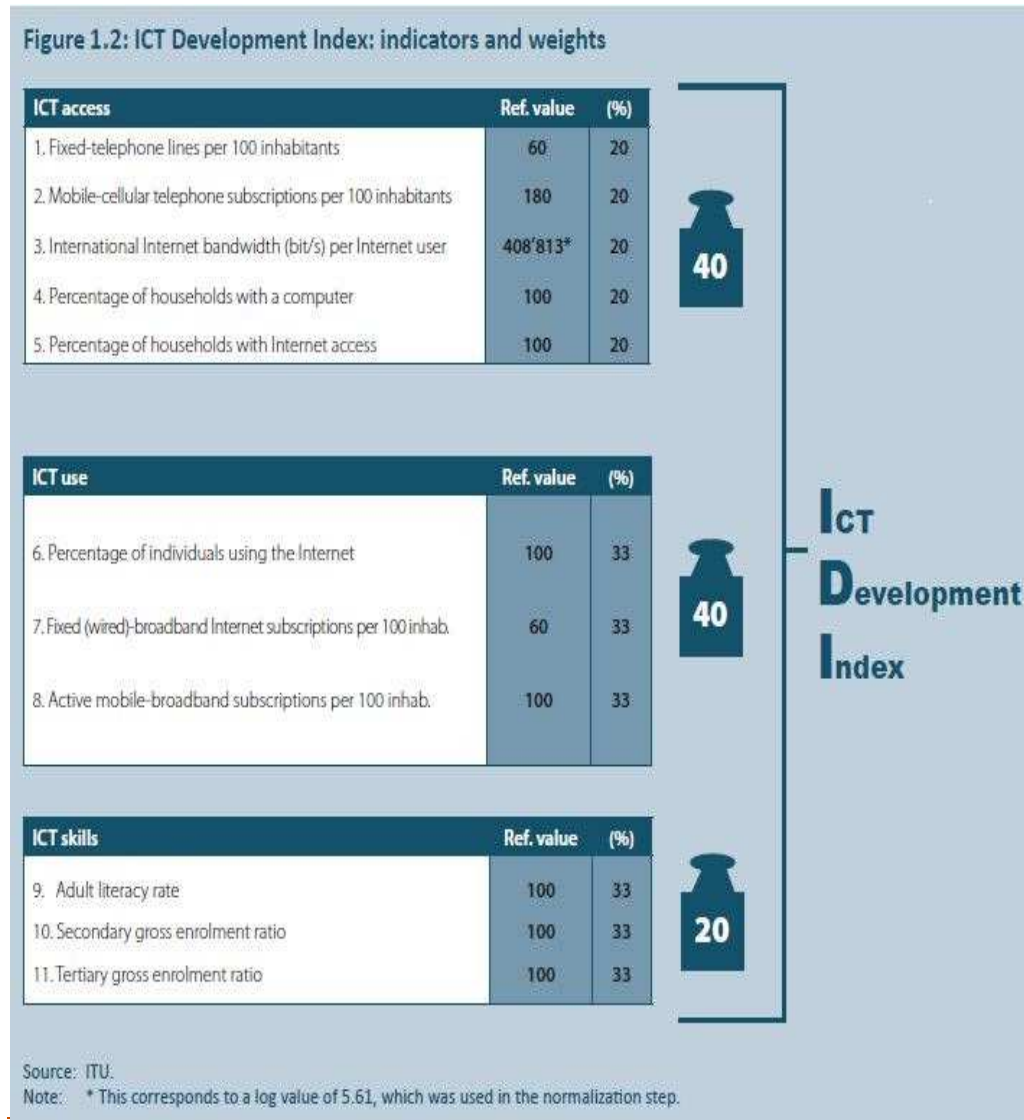
ICT Use

- Percentage of individuals using the Internet
- Fixed (wired) broadband Internet subscription per 100 inhabitants
- Active mobile-broadband subscription per 100 inhabitants

ICT Skills

- Adult literacy rate
- Secondary gross enrollment ratio
- Tertiary gross enrollment ratio

In the report of ICT, it is stated that all indicators are equally weighted in the calculations of sub-indices. Furthermore, the weights of ICT access and ICT use are equal and 40%, and the weight of ICT skills is 20% in the calculation of IDI.

The primary goal of this study is to analyze the most effective factors that cause the differences in the ICT infrastructure and uptake of countries. In this study, ICT Development Index tool has been used in order to compare ICT development of countries.

_____

Figure 1.2: ICT Development Index: indicators and weights

ICT access	Ref. value	(%)
1. Fixed-telephone lines per 100 inhabitants	60	20
2. Mobile-cellular telephone subscriptions per 100 inhabitants	180	20
3. International Internet bandwidth (bit/s) per Internet user	408'813*	20
4. Percentage of households with a computer	100	20
5. Percentage of households with Internet access	100	20

40

ICT use	Ref. value	(%)
6. Percentage of individuals using the Internet	100	33
7. Fixed (wired)-broadband Internet subscriptions per 100 inhab.	60	33
8. Active mobile-broadband subscriptions per 100 inhab.	100	33

40

ICT skills	Ref. value	(%)
9. Adult literacy rate	100	33
10. Secondary gross enrolment ratio	100	33
11. Tertiary gross enrolment ratio	100	33

20

ICT Development Index

Source: ITU.
Note: * This corresponds to a log value of 5.61, which was used in the normalization step.

Fig. 1: ICT Development Index: Indicators and Weights

Data

The explanatory variables of the study are selected based on our literature review of the digital divide. Moreover, the availability of the data for most of the countries for a specific year is another factor for selecting the variables. In this study, the data are collected for 155 countries in the ITU report. As the continuous variables Human Development Index (HDI), Gross National Income per Capita (GNIpc), Life Expectancy at Birth, and Education Index are taken into consideration to analyze their effects on the

_____

IDI and therefore on the digital divide of the countries. As the categorical independent variables that may affect IDI, income and the development levels of the countries are selected. Moreover, continent of the countries and OECD membership information are included in the study to put forward whether these factors have effects on the differences of the ICT levels of countries.

Data Preparation

IDI metrics of countries have been provided from the 2012 edition of 'Measuring the Information Society' report (ITU, 2012). Accurate information of 155 countries is available measuring differences in ICT development of countries. In this report, because there were 2011 IDI metrics, all the other data are collected for year 2011.

Education Index, Human Development Index (HDI), Life Expectancy at Birth, and Gross National Income per capita (GNIpc) information of the countries are acquired from Human Development Report 2011 of United Nations Development Programme (UNDP) (UNDP, 2011). Income levels of the countries are found from World Bank (World Bank, 2013). After adding continent information, OECD membership, and development (developed/developing) information for each country, the data become ready for analysis. Although the IDI tool metrics of 155 countries have been provided by ITU, due to the lack of data of some countries related to other indicators, 145 countries' complete data are included in this study.

The variables and their types are summarized in Table 1.

Table 1: Measurement Levels and Categories of Variables

Variable	Description	Categories	Measurement Levels
Country	Country Names	Listed alphabetically	Qualitative
Continent	Group of Continents	{1, Africa 2, Asia 3,Europe 4,South America 5,North America 6,Oceania}	Qualitative-Nominal
UNDI	United Nations Development Index	{1, Developed 2, Developing}	Qualitative-Nominal
OECD	OECD Membership	{1, OECD 2, not OECD}	Qualitative-Nominal
IncomeGroup	Income Group	{1,Low Income 2, Lower Middle Income 3, Upper Middle Income 4,High Income}	Qualitative-Ordinal
IDI_2011	ICT Development Index (2011)	None	Quantitative-Scale

_____

_____

Variable	Description	Categories	Measurement Levels
HDI2011	Human Development Index(2011)	None	Quantitative-Scale
LifeExpBirth2011	Life Expectancy at Birth (2011)	None	Quantitative-Scale
GNIpc2011	Gross National Income per capita (2011)	None	Quantitative-Scale
EduIndex2011	Education Index (2011)	None	Quantitative-Scale

Methodology and Hypotheses

One-way ANOVA and regression analysis are applied to investigate the significant variables affecting the digital divide which is represented here with ICT Development Index. All the analyses are conducted using SPSS 21.0.

One-way ANOVA: It is used to analyze the difference between IDI_2011 and our categorical independent variables; Continent, UNDI, OECD, Income Group. If significant differences were to be found, the Tukey's HSD Post-hoc test had been conducted in order to determine which group differs from each other in terms of IDI_2011.

Hypotheses:
H1 = There is a significant difference between continents in terms of ICT Development Index.
H2= There is a significant difference between OECD members and others in terms of ICT Development Index.
H3= There is a significant difference between developed and developing countries in terms of ICT Development Index.
H4 = There is a significant difference between income groups in terms of ICT Development Index.

Multiple Linear Regression: This analysis is undertaken to be able to specify which independent variables have a significant effect on ICT Development Index and develop a model using significant variables. Stepwise method is selected to eliminate the effect of multicollinearity between independent variables. The dependent variable is the IDI_2011 of 145 countries in the dataset for 2011, and independent variables are Continent, UNDI, OECD, IncomeGroup, HDI2011, LifeExpBirth2011, GNIpc2011, and EduIndex2011. Dummy variables are created for nominal and ordinal type variables such as Continent, UNDI, OECD, IncomeGroup.

Findings

One-way ANOVA Test

According to the results of the ANOVA, the ICT Development Index of the continents are significantly differ (p=0.0). In order to find out the groups which create differences, Tukey HSD test is applied. The results show that;

- There are significant differences between Africa and all the other continents
- There are significant differences between Asia and Europe
- There are significant differences between Europe and all the other continents except Oceania
- There are significant differences between South America and Europe

_____

_____

Related to OECD membership, it is found that there is a significant difference of ICT Development Index of OECD countries and non OECD countries (p=0.0). OECD member countries have higher ICT Development Index than those non members.

Similarly, there is a significant difference of ICT Development Index of developed countries and developing countries (p=0.0). Developed countries have higher ICT Development Index than developing countries.

Income group is another variable for which the ICT Development Index is significantly differed (p=0.0). In order to find out the groups which create differences, Tukey HSD test is applied. The results show that there are significant differences between all the levels of income groups of the countries and their IDI. Countries having higher income groups have also high IDI.

Multiple Regression Analysis

The stepwise regression analysis results are summarized in Table 2. The F test of the model is found to be significant. According to the results, the significant variables of the model are HDI2011, GNIpc2011, OECD membership, and Continent. Only European countries have different and higher ICT Development Index than the other countries. That's why the dummy variable related to this continent appears in the model with a positive coefficient. All the other coefficients of the significant variables are also positive, indicating that HDI, GNIpc, and OECD membership positively affect the ICT Development Index. We can also state that development levels, Education index, Income Groups, and Life Expectancy at Birth have no significant effects on ICT Development Index. The reason for this may be that, these variables are explained mostly with other significant variables of the model. In other words, they are significant relationships between independent variables of the model, and stepwise method selects most significant variables to explain the dependent variable.

Table 2: Regression Analysis Results

Variables	b	SEb	Beta (β)	t	Sig.
(Constant)	-1.842	.272		-6.763	.000
HDI2011	7.904	.487	.643	16.225	.000
GNIpc2011	2.728E-005	.000	.198	5.758	.000
D_OECD	.732	.157	.146	4.673	.000
Europe	.538	.144	.113	3.737	.000
R^2 .927 Adjusted R^2 .924 SE Estimate .587 F 350.816 Sig F .000					

_____

_____

The R^2 of the model is 0.927 which indicates that very strong relationship exist between the dependent and significant independent variables of the model. Consequently, these variables together can explain the variability of ICT Development Index at a level of 93% in the population. As a result, European and OECD member countries which have higher HDI index and GNIpc, have also higher ICT Development Index. Therefore, we can consider four different cases and their models are as follows:

For countries that are OECD member and located in Europe:
ICT Development Index = -0.572 + 7.904 x HDI + 2.728x10-5 x GNI per capita

For countries that are not OECD member but located in Europe:
ICT Development Index = -1.304 + 7.904 x HDI+ 2.728x10-5x GNI per capita

For countries that are OECD member and not located in Europe:
ICT Development Index = -1.11 + 7.904 x HDI + 2.728x10-5 x GNI per capita

For countries that are not OECD member and not located in Europe:
ICT Development Index = -1.842 + 7.904 x HDI + 2.728x10-5x GNI per capita

Conclusion

Many researchers state that, ICT resources are not divided equally throughout the world. Furthermore, the distribution is not uniform even within the same continent; some countries or regions having different ICT access or having more resources than others. Many socio-economic problems are emerged from imbalance using of ICT resources. This study was conducted to explore the global digital divide among the countries having different development levels. To measure the digital divide ITU's ICT key indicators were used. As the independent variables of the study,

continents, being an OECD country, being a developed country, income levels, Human Development Index, Gross National Income per Capita, Education Index, and Life Expectancy at Birth were selected. The data were collected for year 2011, and one-way ANOVA test and stepwise regression analysis were applied.

The results show that, global digital divide has a significant difference in almost every categorical variable which is studied. There are significant differences between continents, and income levels in terms of ICT Development Index. Similarly, there is a significant difference between developed and developing countries and between OECD member and not member countries in terms of this index. The result of the regression analysis shows that there are significant relations between ICT Development Index, HDI, GNI per capita and continental differences. The first model of the Stepwise model shows that, Human Development Index alone has an effect of 86% on ICT Development Index. By knowing HDI, GNI per capita, OECD membership, and continent of a country ICT Development Index can be predicted at a rate of 93%.

As conclusion, still a significant gap exists between regions and countries in terms of reaching and sharing the information across rapid developments in computer science and information technologies. European and OECD member countries have high ICT Development Index. Among these countries, which have higher HDI and GNIpc, have also higher ICT Development Index. Therefore we can state that digital gap is reduced for these type countries. For the other counties, different actions can be undertaken and most suitable policies can be implemented to reduce the current digital divide.

The study was conducted with 2011 data since later data was not available. For further studies, the similar analyses may be conducted for the following years and compared with the findings of this study.

_____

_____

Moreover, the study can be enlarged using more factors to measure the digital divide.

References

1. Bagchi, K. (2005), 'Factors Contributing to Global Digital Divide: Some Empirical Results,' *Journal of Global Information Technology Management*, 8 (3), 47 – 65.

2. Banker, R., Mitra, S. and Sambamurthy, V. (2011), 'The Effects of Digital Trading Platforms on Commodity Prices in Agricultural Supply Chains,' *MIS Quarterly*, 35 (3), 599–611.

3. Billon, M., Marco, R. and Lera-Lopez, F. (2009), 'Disparities in ICT Adoption: A Multidimensional Approach to Study the Cross-Country Digital Divide,' *Telecommunications Policy*, 33 (10-11), 596-610.

4. Chen, W. and Wellman, B. (2004), 'The Global Digital Divide-Within and Between Countries,' *IT&Society*, 1(7), 18-25.

5. Chinn, MD. and Fairlie, RW. (2007), 'The Determinants of the Global Digital Divide: A Cross-Country Analysis of Computer and Internet Penetration,' *Oxford Economic Papers*, 59 (1), 16-44.

6. Corrocher, N. and Ordanini, A. (2002), 'Measuring The Digital Divide: A Framework for the Analysis of Cross-Country Differences,' *Journal of Information Technology*, 17 (1), 9-19.

7. Crenshaw, EM. and Robinson, KK. (2006), 'Jump-Starting the Internet Revolution: How Structural Conduciveness and Global Connections Help Diffuse the Internet,' *Journal of the Association of Information Systems*, 7 (1), 4–18.

8. Cruz-Jesus, F., Oliveira, T. and Bacao, F. (2012), 'Digital Divide Across the European Union,' *Information and Management*, 49 (6), 278-291.

9. Cuervo, MRV. and Menendez, AJL. (2006), 'A Multivariate Framework for the Analysis of the Digital Divide: Evidence for the European Union,' *Information and Management*, 43 (6), 756–766.

10. Çilan, ÇA., Bolat, BA. and Coşkun, E. (2009), 'Analyzing Digital Divide Within and Between Member and Candidate Countries of European Union,' *Government Information Quarterly*, 26 (1), 98-105.

11. Dewan, S., Ganley, D. and Kraemer, KL. (2005), 'Across the Digital Divide: A Cross-Country Analysis of the Determinants of IT Penetration,' *Journal of the Association of Information Systems*, 6 (12), 409–432.

12. Dewan, S., Ganley, D. and Kraemer, KL. (2010), 'Complementarities in the Diffusion of Personal Computers and the Internet: Implications for the Global Digital Divide,' *Information Systems Research*, 21 (4), 925–941.

13. Dewan S. and Riggins FJ. (2005), 'The Digital Divide: Current and Future Research Directions,' *Journal of the Association for Information Systems*, 6 (12), 298-337.

14. Doong, SH. and Ho, SC. (2012), 'The Impact of ICT Development on the Global Digital Divide,' *Electronic Commerce Research and Applications*, 11 (5), 518-533.

15. Goldfarb, A. and Prince J. (2008), 'Internet Adoption and Usage Patterns Are Different: Implications for the Digital Divide,' *Information Economics and Policy*, 20 (1), 2-15.

16. ITU, 2012. Measuring the Information Society 2012 Report [pdf]-ICT Development Index. [Accessed 22 March 2013]. Available at: http://www.itu.int/en/ITU-D/Statistics/Documents/publications/mis2012/MIS2012_without_Annex_4.pdf.

17. Kiiski, S. and Pohjola, M. (2002), 'Cross-Country Diffusion of the Internet,'

_____

_____

Information Economics and Policy, 14(2), 297-310.

18. Labrianidis, L. and Kalogeressis, T. (2006), 'The Digital Divide in Europe's Rural Enterprises,' *European Planning Studies,* 14(1), 23-39.

19. OECD, 2001. Understanding the Digital Divide [pdf]. [Accessed 15 March 2013]. Available   at: http://www.oecd.org/sti/1888451.pdf

20. Pick JB. and Azari, R. (2008), 'Global Digital Divide: Influence of Socioeconomic, Governmental, and Accessibility Factors on Information   Technology,' *InformationTechnology for Development*, 14 (2), 91-115.

21. Talukdar, D. and Gauri, DK. (2011), 'Home Internet Access and Usage in The USA: The Trends in the Socio-Economic Digital Divide,' *Communications of the Association for Information Systems*, 28, 185–198.

22. Techatassanasoontorn,   AA.   and Kauffman, RJ. (2005), 'Is There a Global Digital Divide for Digital Wireless Technologies?,' *Journal of the Association for Information Systems*, 6 (12), 338–382.

23. UNDP, 2011. Human Development Statistical Annex, Human Development Report [pdf]. [Accessed 1 April 2013]. Available   at: http://hdr.undp.org/en/media/HDR_2011_EN_Complete.pdf

24. Vicente, MR. and López AJ. (2008), 'Some Empirical Evidence on Internet Diffusion in The New Member States and Candidate Countries of the European Union,' *Applied Economics Letters*, 15 (13), 1015-1018.

25. World Bank, 2013. World Development Report [online]. [Accessed 9 April 2013]. Available   at: http://wdronline.worldbank.org/worldbank/a/incomelevel

26. Zhao, H., Kim, S., Suh, T. and Du, J. (2007), 'Social Institutional Explanations of Global Internet Diffusion: A Cross-Country Analysis,' *Journal of Global Information Management*, 15 (2), 28-55.

_____