HAL open science

A Visual Uptake on the Digital Divide

Farooq Mubarak, Reima Suomi

To cite this version:

Farooq Mubarak, Reima Suomi. A Visual Uptake on the Digital Divide. 14th Conference on e-Business, e-Services and e-Society (I3E), Oct 2015, Delft, Netherlands. pp.398-415, 10.1007/978-3-319-25013-7_32 . hal-01448057

HAL Id: hal-01448057

https://inria.hal.science/hal-01448057v1

Submitted on 27 Jan 2017

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Distributed under a Creative Commons Attribution 4.0 International License

A Visual Uptake on the Digital Divide

Farooq Mubarak[1] & Reima Suomi[2],

[1]Turku School of Economics, Department of Information Systems Science, University of Turku, Finland.
farmub@utu.fi

[2] Turku School of Economics, Department of Information Systems Science, University of Turku, Finland.

reima.suomi@utu.fi

Abstract. Factors found to influence the adoption of ICT have been explored in several studies. However, few writers have been able to produce any systematic research into the digital divide. Although, differences of opinion still exist, a growing body of literature has established that income and education are positively related to digitalization patterns. This research attempts to deepen the understanding of the present ambiguous relationship between socio-economic indicators and the ICT. This account tested the links between socio-economic variables (GDP per capita, GINI index, World Bank Education Statistics, and Transparency International's corruption perception index) and ICT diffusion across developed and developing countries. Positive correlations were found for income and ICT, education and ICT. A negative correlation was found between corruption and ICT adoption. The paper discusses implication of these findings and suggests future courses of actions for policy makers. Proceeding from the findings of this paper, this research suggests there is an urgent need to address the digital divide by initiating impactful efforts to reduce it.

Keywords: Digital divide, ICT, Digital technologies

1 Introduction

Researchers have long sought to determine how patterns of digitalization link with economic variables. To that end, a hefty volume of publications has appeared in academia that looks at such links that have a variety of well-disputed varying research methods and measurement mechanisms. Moreover, recent advancements in ICT research have laid rest to several myths concerning the nature of the digital divide. Nevertheless, much doubt still persists since there still appears to be little agreement on the leading causes of the digital divide. The past decade, in particular, has seen rapid progress in ICT research, which has reshaped the conventional concept of the digital divide from narrow to wide and made it considerably complex paradigm. This shift

has resulted in mounting literature across academia, politics, and the press. Much of the existing debate on the digital divide revolves around the qualitative nature of the issue, while the quantitative uptake on the topic appears to be overlooked. Thus, Noh & Yoo [1] view the measurement of the digital divide as a controversial issue. Owing to the complexities of the subject, some researchers [2, 3, 4] state that the digital divide is a confused theme in literature. These critics justify their views by noting severe pitfalls of the data and methodologies used to quantify the digital divide.

In the history of the digital divide, poverty has been thought of as a key factor that is responsible for the breach in the access and the utilization of the digital technologies. In their major analysis of publications from thirty leading researchers, Skok and Ryder [5] concluded that GDP per capita and education were the principal factors responsible for the digital divide. A similar result was reported by Billon, Lera-Lopez, and Marco [6] who found GDP and infrastructure as to be the main factors for slow digital progress in developing countries. A number of researchers [e.g. 7, 8, 9] have acknowledged GDP per capita/income as a leading cause of the digital divide between and within countries. It appears safe to say that poverty alone explains a major portion of the digital divide outgrowth.

The connections between GDP per capita and patterns of digitalization have been an object of research since the evolution of the digital divide concept, in the mid-1990s. Vodoz, Reinhard, and Giauque [10] noted that individuals with higher education levels are likely to adopt the digital technologies faster than people with low or no education at all. Two large-scale studies [11, 12] demonstrated the positive correlation between GDP and the Internet diffusion curve.

However, uncertainty still exists about the relation be-tween education and ICT diffusion; and two major studies [13, 14] defy any relation between the two. Consonantly, Stanley [15] intensifies psychosocial resistances as key factor responsible for the digital divide, thus putting aside income and education. Nevertheless, considerable criticism has been levelled at quantitative research on the digital divide. Much of the research on this subject has been restricted to local and limited comparisons, while only a few studies such as those by Cruz-Jesus et al. [14] have attempted to assess the digital divide across a wide range of geographical territories.

The recent rise in public computer facilities in developed countries has allowed a large segment of the population to benefit from ICT, who otherwise could not afford computers and the Internet. Thus, it can be fairly argued that there exists a category of people in developed countries who can benefit from ICT regardless of in-come constraints. If the findings made by Vodoz et al. [10] about the high rates of ICT adoption on education being dependent on education are accurate, then what explains the exponential growth of the Internet in developing regions with low literacy rates, such as South-East Asia? What is not yet clear is the measured impact of income and education on ICT adoption in the current era. Despite the research mentioned earlier, there is still very little scientific understanding of the degree of the relationship if any, of socio-economic indicators with ICT, particularly in developed countries. In addition, the general dispute in the quantitative literature on the digital divide hints that much of the evidence so far is inconclusive at best. This indicates a need to understand the various perceptions of any possible connections of socio-economic indicators with

ICT in this current age. For the purposes of this study, the chosen socio-economic variables are the World Bank GDP per capita, the GINI index, World Bank Education, and Transparency Inter-national's Corruption Perception index.

Even though, some research has studied the socio-economic links with ICT, most research has been undertaken by analyzing just a few statistical observations. Nonetheless, it is possible to further improve the research design and scope by utilizing a combination of methods. With this goal, the present research seeks to obtain visualizations of the major factors that are responsible for the digital divide. Drawing upon this stand of research into the digital divide, this paper shall attempt to verify the aforementioned claims in preceding paragraphs by examining the links between income, education, and corruption with ICT patterns across high-income Nordic countries, the low-income Indian sub-continent region, and a few middle-income countries. A secondary aim is to shed light on the implication of the findings and suggest a direction for possible future developments. This paper aims to broaden the scope of the main factors responsible for the digital divide, since the digital disparities are intermixed with social and psychological factors in addition to income and education. The hypothetical premises at this point rest on four assumptions: GDP per capita is positive related to Internet adoption, GINI index is inversely related to Internet adoption, education is positively related to Internet adoption, and Corruption is inversely related to Internet adoption.

2 Literature review

During the past twenty years, much more information has become available on the digital divide and its rigorous threats to the world economy. However, very little was found in the literature on the question of quantitative analysis of the digital divide. The digital divide can be defined as the disparity between those who do and do not benefit from digital technologies [16]. In the context of the digital divide, the chief division is between two significant groups namely inclusion and exclusion with respect to those who benefit and those who do not benefit from digital technologies. One group consisting of developed countries is continuously reaping the benefits of ICT whereas the other group consisting of developing countries is missing out on many benefits due to lack of access to the digital technologies [17, 18]. Menou [19] and Mansell [20] already warned that if the issue of the digital divide is left unattended, world inhabitants will be living in a dual planet. Call for future research on the nature of the digital divide has been a recurring theme of many scholarly articles.

As noted in the introduction that digital divide has been viewed as a confused theme in literature: some studies [19, 21, 22] consider the digital divide to be a matter of gap in access to ICT while others [1, 23, 24, 25 26, 27, 28, 29, 30] consider the digital divide as a complex and broad phenomenon where several variables play their respective part. Pick & Nishida [31] found education to be the principal determinant of technology utilization. It can be inferred from the study´s conclusion that the role of education is significant in increasing adoption of digital technologies. Similarly, Cooke & Greenwood [32] maintain that the educational sector has made significant

progress in promoting the adoption of ICT. Pittman [33] postulates that the role of ICT is essential in fostering a globally diverse educational system.

However, recently some literature has emerged that offers contradictory findings regarding the role of education in ICT adoption. An empirical investigation led by Lee [34] suggests that demographic factors (age, gender, education) have little effect on the digital divide. Unlike Pittman [33], a survey study of 158 Small and Medium Enterprise (SME) owners by Middleton and Chambers [13] found that education has no effect on the adoption of Internet. However, this attitude would appear to be outdated even the study was published in the year 2010. There are limits to how far the idea of Middleton and Chambers [13] can be taken because ICT is being increasingly incorporated into the education systems worldwide.

Tipton [7] and Olaniran & Agnello [8] document income disparity as the leading cause of the digital divide by noting that the digital divide reflects high income levels in developed world where as the opposite is true for the developing world. Quibria et al. [12] report a strong correlation between GDP per capita and the usage of computer. However, Tavani [27] develops the claim that there are numerous other factors responsible for the breach in access and utilization of ICT other than income alone. Brooks et al. [9] maintain that costs of Internet connectivity in developing countries is significantly higher than those in developed countries. This corroborates with the view of Norris [35] who maintain that the richer countries are better in reaping the benefits of ICT than the poorer countries. The evidence presented in this paragraph suggests that there is a strong connection between GDP per capita and the patterns of digitalization. However, a number of studies [e.g. 14, 36, 37; 38, 39] have reported significant digital divide in developed countries, which questions the relation of GDP with the ICT diffusion. This doubt is further reinforced since some researchers [40 , 41] report a regional digital divide with respect to urban and rural settlements in high-income developed countries.

Novo-Corti, Varela-Candamio, & García-Álvarez [42] maintain that simply promoting the access to digital technologies is a simple solution to overcome the digital divide. Although, the study was targeted towards a particular region, the claim is question-able because the digital divide has been proved as a complex phenomenon and a variety of factors are responsible for the di-vide other than just access. Bach, Zoroja, and Vukšić [43] calls for effective policies for organizations and governments to com-bat the digital divide. This corroborates with the findings of Graham [44] who highlights the need of effective government systems with effective subsidies to minimize the digital divide. Peng [45] points out that although governments have access to household profile data such as education, income, and gender, they often lack reliable insights into psychological and cognitive profiles of individuals. This implies that efforts to fight the digital divide are required on multiple fronts since other than income and education; psychological factors are also responsible for adoption / non-adoption of ICT.

The insights drawn from the literature review advances us towards testing three hypothesis. First, income per capita bears a positive relation with ICT adoption. Second, education has a positive link with ICT adoption. Finally, corruption bears negative relation with ICT adoption.

3 Research design

3.1 Methodology

To date various methods have been developed and introduced in order to determine the connection between two or more variables. Traditionally, the digital divide measurements have been studied by comparing the variables in a select geographical territory. In addition, correlations between these variables have also been calculated to measure the degree of relationship. In the present study, the visualization approach was chosen to represent the association of GDP and education with the digitalization patterns across OECD member countries. The correlation attempt to provide an estimate of the degree of association between the variables under consideration. The correlations were calculated by using the following formula.

$$r = \frac{1}{n-1} \Sigma \left(\frac{x - \overline{x}}{s_x} \right) \left(\frac{y - \overline{y}}{s_y} \right)$$

Where r is the coefficient of correlation, X and Y are variables, whereas x bar and y bar represent respective sample means. S represents the sample standard deviation of the respective variables x and y. n equals the number of items in the samples under consideration. Pearson product correlations from the above mentioned formula were calculated between the variables under consideration after each figure. The average values of the data sets were taken for the available years, wherever possible. In some cases, data was missing for some countries in specific years; thus only years with complete data for all countries were taken into consideration.

3.2 Data Selection

Although, a range of different organizations provide data sets for GDP and similar economic indicators, this research employed data from World Bank statistics database. In addition to the simplicity of the data downloads according to the customized preferences, World Bank statistics are known for providing credible information. The statistics were also found to be in close accordance with data provided by other institutions, although there were minor differences. PISA test scores were taken directly from the official PISA scores website. The corruption Perception Index was taken from the Transparency International official website. For the purposes of the present study, information from the developed Nordic countries, developing Indian subcontinent countries and a few middle-income countries was chosen. In some instances, the data for some countries was not available for a particular indicator; therefore different countries were added to the comparison. The data sources are detailed in Table 1.

Table 1. Data sources

Name	Institution	URL	Selected data source	URL

Education efficiency	PISA-test scores	*www.oecd.org/pisa*	Scores in mathematics	http://www.oecd.org/pisa/keyfindings/pisa-2012-results.htm
Income	World Bank	*www.worldbank.org*	GDP per capita	*data.worldbank.org/indicator/NY.GDP.PCAP.CD*
Income inequality	World Bank	*www.worldbank.org*	GINI index	*data.worldbank.org/indicator/SI.POV.GINI*
Corruption	Transparency International	*www.transparency.org/country*	Corruption Perception index	*www.transparency.org/research/cpi/overview*

3.3 Visualizations

Human brains are designed to process visual images before texts, and they need less energy to consume images than texts [46]. In particular, visualizations present clear pictures of possible trends where the data is vast. Therefore, visualizations were chosen as a means for seeing any connections between the variables. In addition to giving a clear picture of a major scenario, visualizations can also represent the predictability of a certain variable's behavior over time.

In the present study, there are a mix of developed and developing countries under consideration. After trying various visualizations in Microsoft Excel software, a few were selected because they tend to report the best trends between the variables. Charts were used to show any possible link between the two variables.

4 Results and discussion

4.1 Results

The visualizations revealed several interesting insights, a few of which negate previous studies. In the forthcoming paragraphs, each figure shall be discussed and all possible interpretations shall be subsequently drawn in the next section of discussion.

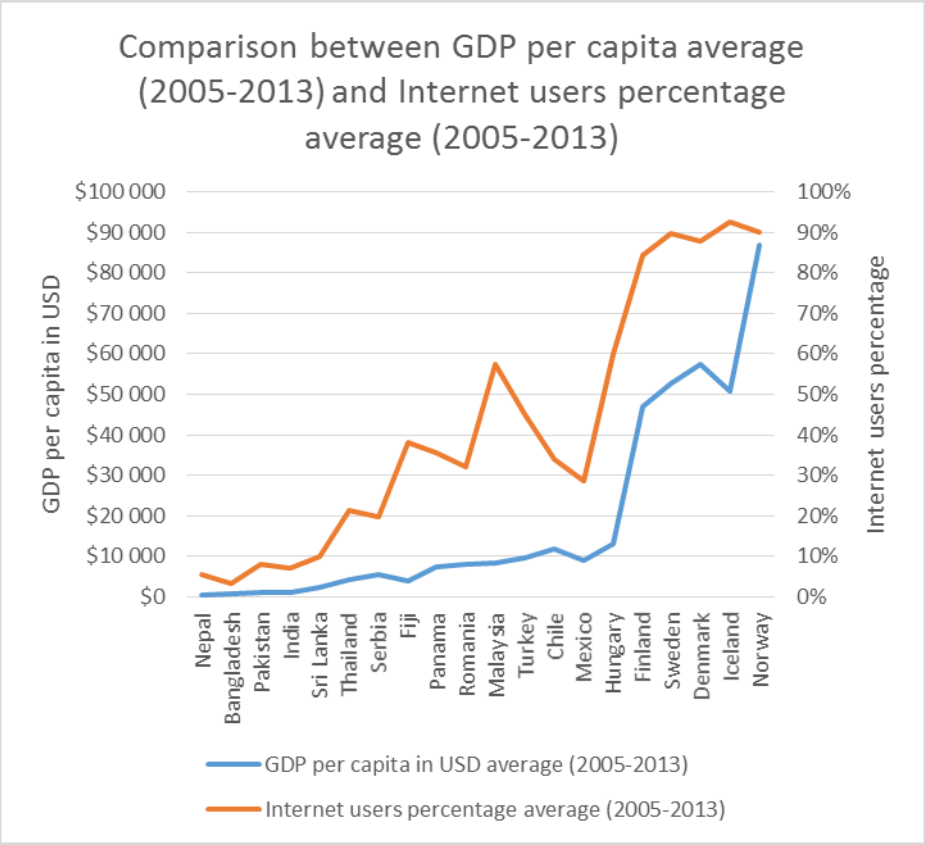

Fig. 1. Comparison between GDP per capita average (2005-2013) and Internet users' percentage average (2005-2013) (Based on World Bank 2015)

Table 2. Correlation between PISA 2012 test scores and the percentage of Internet users

Emerging correlation in figure 2	
Correlation between GDP per capita average (2005-2013) and Internet users percentage average (2005-2013)	0.882

Figure 1 shows that a positive parallel relation was found between GDP per capita and Internet users per hundred people in developed and developing countries. The Pearson product correlation coefficient "r" was found to be 0.882. The positive correlation suggests that there is a tendency for increase in the number of Internet users with an increase in the GDP per capita of a given country. It can be seen from figure that Norway has the highest GDP per capita and the highest percentage of Internet users. Along with Norway, other Nordic countries show high rates of GDP per capita

and percentage of Internet users. This is in stark contrast with the Indian subcontinent countries which show low rates of GDP per capita and Internet users.

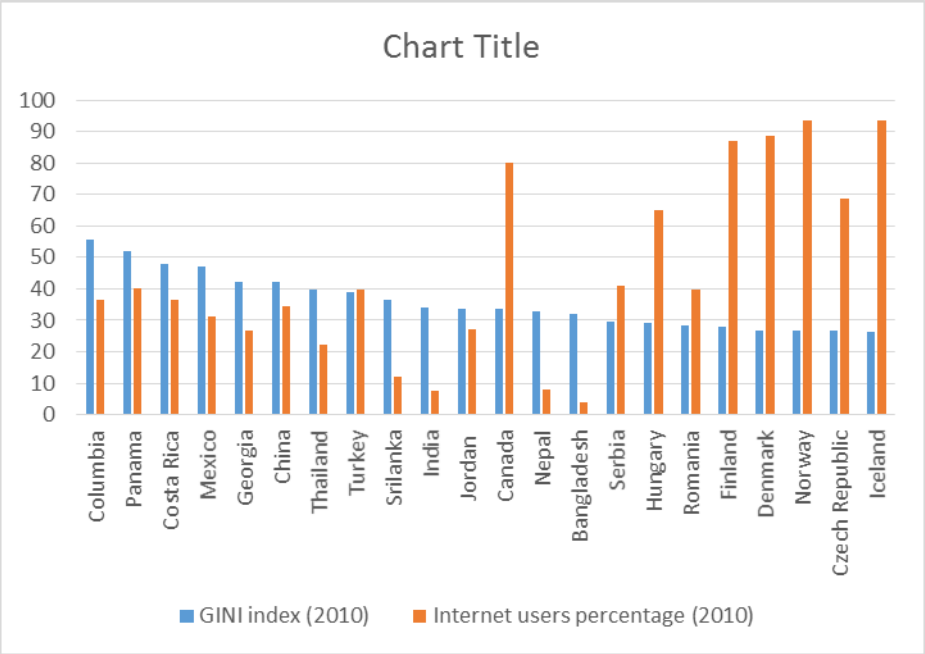

Fig. 2. Comparison between GINI index 2010 and Internet users 2010 (Based on World Bank 2015)

Table 3. Correlation between GINI index in percentage (2010) and Internet users in percentages (2010)

Emerging correlation in figure 2	
Correlation between the GINI index in percentages (2010) and Internet users in percentages (2010)	-0.45

Figure 2 compares the GINI index with the Internet user's percentage across a range of developed, developing, and middle-income countries. A general trend that can be noticed from the figure 2 that higher the GINI index, lower the Internet users percentage. For instance, Iceland has the lowest value of GINI index and the highest number of Internet users percentage along with Norway. Thus, it can be inferred that higher the inequality of income in a given country, lower shall be the ICT adoption, in general. There are however exceptions to this rule. For example, GINI index values of Nepal and Bangladesh are almost same, however Nepal shows considerable high percentage of Internet users. This negative result might be due to other factors such as political and regional infrastructure differences. The correlation analysis yielded a

negative value of -0,45 indicating a negative link between inequality of income and Internet usage.

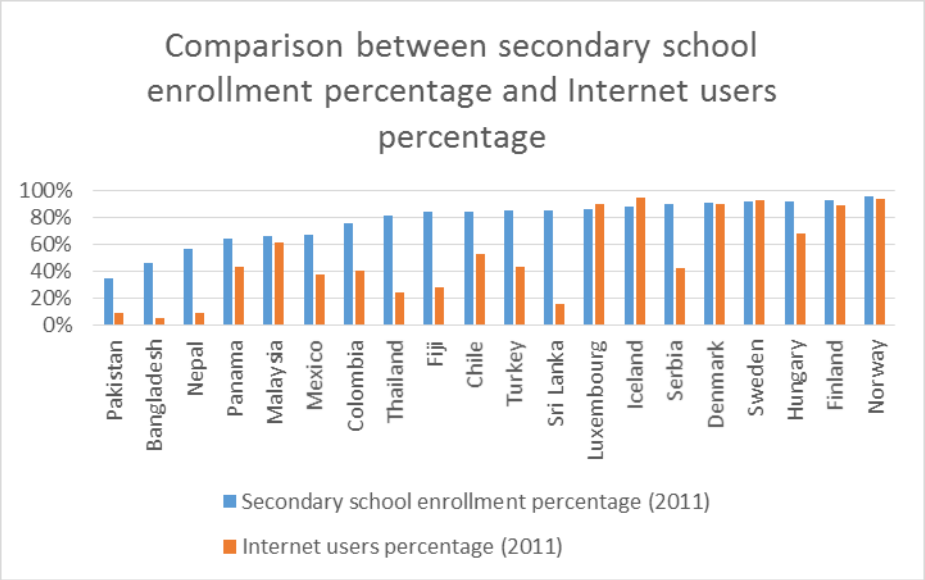

Fig. 3. Comparison between the percentage of secondary school enrollment and the percentage of Internet users for the year 2011

Table 4. Correlation between the percentages of secondary school enrollment and the precentage of Internet users

Emerging correlation in figure 3	
Correlation between the percentages of secondary school enrollment and Internet users	0.699

Figure 3 compares percentages of secondary school enrollment and Internet users across Nordic, few Indian subcontinent countries for which data was available, and middle-income countries. Comparatively less intense than the correlation between GDP per capita and Internet users, however, still a positive correlation between secondary school enrollment and Internet diffusion was found to be 0.699 as reported in Table 3. All Nordic countries show high percentages of secondary school enrollments and Internet users, whereas countries in Indian subcontinent region show low values of both variables under examination. There are however exceptions to this general trend of parallel growth of secondary school enrollments and Internet users. For instance, Luxembourg and Sri Lanka have almost similar values of secondary school enrollments at 86,4 % and 85,4% respectively but they differ remarkably in percentage of Internet users. Despite the high secondary school enrollments rate, Sri Lanka has only 15 % of Internet users as compared to 90,02% in Luxembourg.

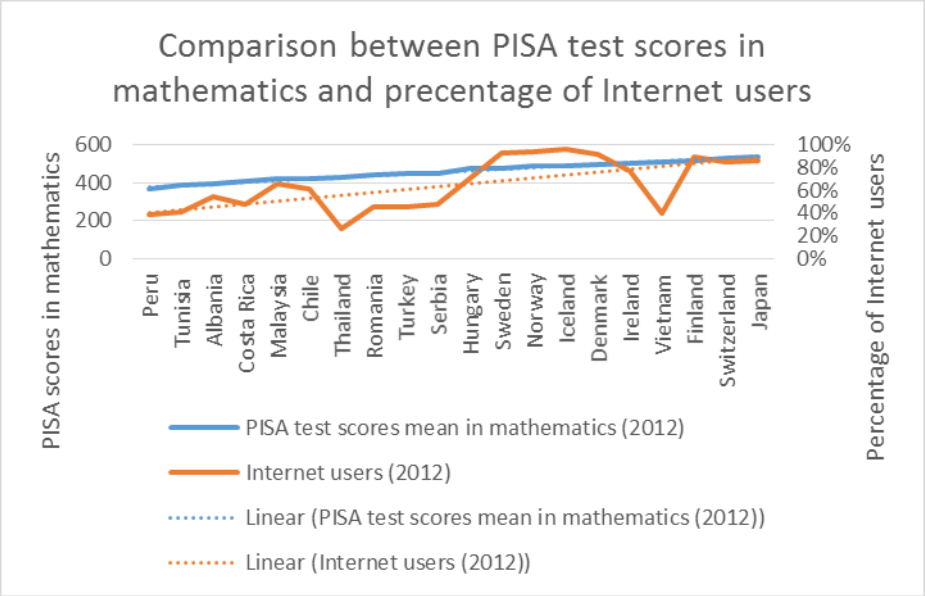

Fig. 4. Comparison between PISA 2012 test scores in mathematics and the percentage of Internet users (Based on data from OECD 2015 and World Bank 2012

Table 5. Correlation between PISA 2012 test scores and the percentage of Internet users

Emerging correlation in figure 4	
Correlation between PISA 2012 test scores and Internet users percentage	0.693

Advancing the comparison between education and ICT, PISA test results were included in the analysis. Since, the Indian subcontinent countries did not take part in PISA test, a different set of developing and developed countries were taken into account. It can be inferred from the figure 4 that countries with high PISA test scores have high percentage of Internet users, suggesting a positive relation between the two. However, there are exceptions to this assumption. For example, Vietnam and Finland show almost same values of PISA test scores, however they vary considerably in terms of Internet users percentage. Finland has far higher percentage of Internet users at 89,88% than Vietnam at 39,50%. The correlation between the subject variables in figure 4 was found to be 0,693 as reported in table 4. The positive value of the correlation at 0,693 suggests a positive link between PISA test scores and Internet usage. The findings from figures 3 and 4 are close to the previous findings of Vodoz et al. [10] and Skok & Ryder [5] who determined education to be a principal factor responsible for ICT adoption

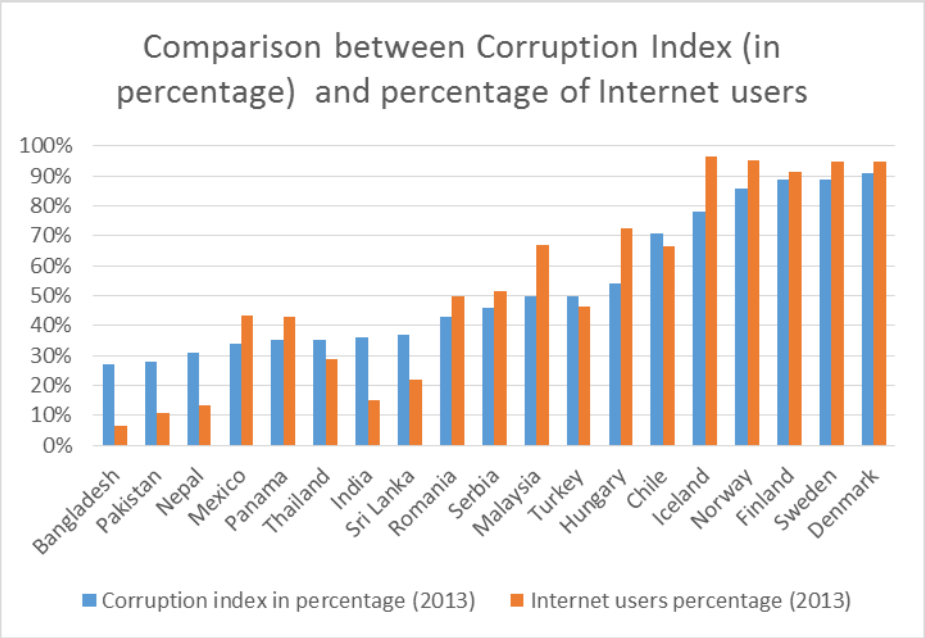

Fig. 5. Comparison between Corruption perception index and Internet users (Based on data from Transparency International Secretariat 2015 and World bank 2015)

Table 6. Correlation between Corruption perception index and Internet users

Emerging correlation in figure 9	
Correlation between Corruption perception index in percentage (2013) and Internet users (2013)	0,933

Figure 5 illustrates how the corruption affects the percentage of Internet users. Corruption perception index shows the percentage of cleanliness in a given country. Figure 5 depicts that Denmark is the cleanest country in terms of corruption and has a high rate of Internet users. This is closely followed by Finland, Sweden, and Norway who are clean from corruption and show high Internet users percentage. On contrary, Bangladesh is the most corrupt country and has the lowest percentage of Internet users. It is apparent from this figure that more the cleanliness from corruption in a given country, more the percentage of Internet users. Correlation between Corruption perception index and Internet users was found to be 0,933. The high positive value of correlation at 0,933 indicates a significantly strong correlation between cleanliness from corruption in a country and Internet usage.

Taken together, these visualizations and correlations lend some support to test the hypothetical assumptions introduced in the beginning of the study. The results of the hypothetical testing is tabulated in the table 5. In summary, the results support the

assumptions presented in the introduction. The next section, therefore, moves on to discuss the findings and their implications in detail.

Table 7. Results **of hypothesis**

Hypothesis	Measuring factor	Hypothetical statements	Calculated correlations	Results
H1:	Income	GDP per capita and the rate of Internet use are positively related	0.89	Supported
		Inequality of income (GINI index) is inversely related to Internet user	-0.45	Supported
H2	Education	Secondary school enrollment and the rate of Internet use are positively related	0.699	Supported
		PISA test scores and the rate of Internet use are positively related	0.693	Supported
H3	Corruption	Corruption is inversely related to the rate of Internet use	0.933	Supported

4.2 Discussion

This study set out to determine the possible links between socioeconomic indicators and ICT in developed and developing countries. It was hypothesized that income and education are positively related to ICT adoption whereas inequality of income and corruption were negatively associated with ICT adoption. As mentioned in the introduction and literature review, the abundant studies on the digital divide show no definite consensus on above mentioned links to draw any firm conclusions. Results of this study indicate that indeed income and education have a positive link with ICT whereas corruption bears a negative relation.

As shown in the literature review, there has been an inconclusive debate about whether education bears any considerable link with ICT or not. Although, there have been a few dissenters to the view that education and ICT bears any significant relation; the present research dispels this view by noticing a positive correlation between education and Internet use from two stand points. First, secondary school enrollment appears to be positively related to Internet use. Second, countries with high scores of PISA test results often show high penetration of Internet.

Correlation between GDP per capita and Internet diffusion was significantly higher than the correlation between secondary school enrollment and Internet diffusion. This leaves room for interpreting that income disparity is the ruling factor responsible for the digital divide. The result emerging from the correlation between educational fac-

tor and Internet diffusion is consistent with the views of Le (2010, 84), who maintains that education has little effect on the adoption of digital technologies. However, reader must bear in mind the ease of access to public free Internet in developed countries; opposite results are likely for developing countries where one may only / mostly tie knot with digital technologies for the purposes of higher education.

A possible explanation for a slight degree of correlation be-tween education and ICT might be that modern modes of education themselves encourage the adoption of digital technologies. ICT has been integrated with education on a global scale excluding misfortunate poverty ridden areas. It then follows that in order to continue the education; one has to utilize ICT, which may be the main motivator behind the purchase decision of digital technologies. This finding has important implications for strengthening the education systems particularly in the developing countries. Education and ICT in several developing countries are ridiculously expensive leaving millions of masses behind, for them needs of education and ICT are pushed aside by basic human needs of food and shelter. Poverty once again wins in breeding nuances of low standards of living including considerable portion of the digital divide pie. Governments particularly in the developing regions should therefore concentrate on providing ICT-enhanced education at reasonable costs for masses. Ideally, however, the solution should rest somewhere near providing free education and access to ICT wherever it is feasible.

The results of this study will now be compared to the findings of previous work. Present findings are consistent with earlier re-search (Tipton [7]; Norris [35]; Olaniran & Agnello [8]) which documents income disparity as the principal reason for the digital disparities in the world. While the current findings about positive relation between education and ICT corroborates with Lee [34], they negate with the results of Middleton & Chambers [13] who report that education has no effect on the ICT adoption. This difference urges itself as an evidence of dispute in the research concerning factors responsible for the digital divide.

Turning now to the hypothesis posed at the beginning of the study, it is now possible to state that income factor rules as the leading cause of the digital divide: however, education has slight effect on ICT adoption. Current research appears to validate the assumption that corruption and inequality of income are negatively associated with ICT use. This combination of findings provides some support for the conceptual premise that poverty is mainly responsible for breeding the nuances of the digital divide. An implication of this could be to provide subsidies on ICT related products so that masses can reach and bene-fit from the digital revolution.

Among various lasting divides on accounts of wealth, health and standards of living, the digital divide is becoming increasingly difficult to ignore due to strong ties of ICT with economic growth and wellbeing. Despite massive progress in the digital technologies over the past twenty years, the ICT diffusion re-mains regrettably uneven at a global scale. The underlying threats posed by the digital divide have been globally acknowledged across press and policy discourses, resulting in the production of various publications and action plans. Fortunately, there are good policies by OECD and International Telecommunications Union in the battle against the digital divide; unfortunately, the action plans in these policies are often poorly calibrated

across different countries. Among various reasons, one obvious reason for inappropriate action plans by governments lies in the fact that the quantitative nature of the digital divide is significantly overlooked in the literature.

Researchers seem to have routinely confused technology access divide with the digital divide over the span of a decade since the evolution of the digital divide concept in the mid-1990s. The heated debate on the digital divide over the past decade left a considerable room for interpreting the digital divide as a broad and complex phenomenon. Soon it was established that breach in technology access was a small portion of the giant digital di-vide; the need for further research into the digital divide be-came even significant than earlier. Today, the digital divide breaks along multiple fronts ranging from individual to a global scale. This broadly indicates that the digital divide can be best tackled by initiating efforts from multiple ends.

As was noted in the introduction of this paper, poor quantitative understanding of the digital divide seriously impedes governments´ abilities to form appropriate frameworks to minimize the digital divide; it becomes increasingly difficult to ignore the poorly understood quantitative aspect of the digital divide. Measurement of the digital divide is a classic problem often noted for deployment of unreliable data in the analysis. Once an adequate quantitative understanding of the subject is established and universally acknowledged, the mission to minimize the digital divide can be crystallized faster than ever before.

Prior research has stressed enough that governments should deploy superior strategy by focusing on weakening the roots of the digital divide rather than just providing access to ICT assuming that the market forces shall eliminate the digital divide over time. Unless governments execute impactful policies, the digital divide shall remain a dilemma for already troubled world economy.

5 Conclusion

5.1 Summary of findings

This study was undertaken to verify the links of socio-economic indicators concerning GDP per capita, GINI index, education, and corruption with ICT. The present paper has given an account of validated positive links between income along with education and Internet usage. While there has been considerable research on the digital divide, only few studies have attempted to investigate the quantitative nature of the digital divide on a large scale. The doubt in existing quantitative accounts of the digital divide is reinforced by the distaste several researchers have in the data and methodologies used for analysis. Therefore, this study has taken a unique visualization approach with measured degree of covariance to provide a confirmatory evidence of any emerging relation between the factors under current examination.

Paired with literary clues, the visualizations paint a compelling picture in support of the hypothesis posed at the beginning of this study. This study has shown a positive association of income with levels of ICT penetration and a marginal correlation between education and ICT across an array of low-income, middle-income, and high-

income countries. Present research has also shown that corruption has is inversely related to Internet usage. The present study confirms the previous findings about income and ICT relation and contributes additional evidence that the increasing GDP per capita determines increasing ICT adoption rate. Among the plausible explanation for this finding is that high purchasing power encourages investment in general. Nevertheless, the results of this study do not support the idea that education and ICT are very highly related with each other. It is, however, not an inalterable rule because in some countries, poor can benefit from free public access to computers and Internet regardless of income / education levels.

The work contributes to existing knowledge in digital divide by strengthening the views of previous research and noting that there exists a dispute in literature regarding the relation of education and ICT. However, low degree of correlation between education and ICT found in this research cannot be extrapolated to the developing world where there is not widespread free public access to ICT and one must purchase the digital technologies for education purposes. The present findings also leave significant room for blaming poverty as the leading cause of the digital divide. It is possible to state that poverty alone breeds a significant proportion of the digital divide; nevertheless other factors such as motivation to adopt ICT, education, forced adoption of ICT due to work requirements, and cultural norms are important to consider when addressing the issue of the digital divide.

The practical implication of these findings is that governments must start efforts on multiple fronts to round up the economic threats posed by the digital divide. On the basis of the evidence currently available, it is possible to suggest that the education in developing countries should be made easily affordable to the poor masses if not totally free. While the poverty breeds the digital divide, the digital inclusion would breed economic development due to enhanced workforce. Overtime, the economic and social benefits of affordable education and ICT shall outweigh the sacrifice in monetary costs by the governments.

Press and policy documents in the name of effective policies against the digital divide shall remain fruitless without pronouncing a decisive aggression against the digital divide on a global scale. The relentless objections to the existing accounts on quantification of the digital divide make it advisable to reconsider the methodology and data used for analysis in future research on the topic. It appears that the crowning success in the battle against the digital divide would require a thorough grasp of both quantitative and qualitative nature of the digital divide. It is a high time to change the course of the digital divide history by initiating impactful efforts on multiple fronts, preferably on determining the mechanism to accurately quantify the digital divide. The digital divide has caused severe havoc to socio-economic lives of millions of people, not to mention its deadly impact on economic footings. Unless there are concrete moves by the governments against the digital divide, the gap between inclusion and exclusion groups shall continue to pose rigorous threats on the world economy.

5.2 Limitations

The findings in this paper are subject to at least two main limitations. First, the chosen data was only from World Bank database in addition to official PISA website and Transparency International website; a wiser approach could have been to perform the statistical analysis with data from different databases and then compare the results. Second, few variables representing education such as PISA results and secondary school enrollments were included in analysis. The present research might have been enriched by including several representative variables of education and ICT diffusion in analysis.

5.3 Future directions

A natural progression of this work would be to analyze the links tested in this study in the developing world. There is abundant room for future progress in determining the links between ICT and other indicators of the economy. Research questions that could be asked include link of ICT with education at different levels, effect of free public ICT access enters on the relation between income and ICT diffusion, comparing the education and income relations with ICT in OECD member states with developing countries. Future work on exploring such connections with different variables shall help to understand patterns of ICT diffusion from multiple perspectives. Further research might explore the links of cultural influences and cognitive factors with ICT adoption on a broad scale including developing and developed countries. The present slow progress in the digital divide projects a poor quantitative understanding of the subject. Therefore, the future research should concentrate on finding reasonable ways to quantify and measure the digital divide.

6 References

1. Noh, Y.-H. and K. Yoo, *Internet, inequality and growth.* Journal of Policy Modeling, 2008. **30**(6): p. 1005-1016.
2. Butcher, M.P., *At the foundations of information justice.* Ethics and Information Technology, 2009. **11**(1): p. 57-69.
3. Hilbert, M., The end justifies the definition: The manifold outlooks on the digital divide and their practical usefulness for policy-making. Telecommunications Policy, 2011. **35**(8): p. 715-736.
4. Van Dijk, J.A., Digital divide research, achievements and shortcomings. Poetics, 2006. **34**(4–5): p. 221-235.
5. Skok, W. and G. Ryder, An evaluation of conventional wisdom of the factors underlying the digital divide: a case study of the Isle of Man. Strategic Change, 2004. **13**(8): p. 423-428.
6. Billon, M., F. Lera-lopez, and R. Marco, Differences in digitalization levels: a multivariate analysis studying the global digital divide. Review of World Economics, 2010. 146(1): p. 39-73.

7. Tipton, F.B., Bridging the digital divide in Southeast Asia: Pilot agencies and policy implementation in Thailand, Malaysia, Vietnam, and the Philippines. ASEAN Economic Bulletin, 2002. **19**(1): p. 83-99.
8. Olaniran, B.A. and M.F. Agnello, *Globalization, educational hegemony, and higher education.* Multicultural Education & Technology Journal, 2008. **2**(2): p. 68-86.
9. Brooks, S., P. Donovan, and C. Rumble, *Developing Nations, the Digital Divide and Research Databases.* Serials Review, 2005. **31**(4): p. 270-278.
10. Vodoz, L., M. Reinhard, and G. Barbara Pfister, *The farmer, the worker and the MP.* GeoJournal, 2007. **68**(1): p. 83.
11. Zhang, X., Income disparity and digital divide: The Internet Consumption Model and cross-country empirical research. Telecommunications Policy, 2013. **37**(6-7): p. 515.
12. Quibria, M.G., et al., *Digital divide: determinants and policies with special reference to Asia.* Journal of Asian Economics, 2003. **13**(6): p. 811.
13. Middleton, K.L. and V. Chambers, *Approaching digital equity: is wifi the new leveler?* Information Technology & People, 2010. **23**(1): p. 4-22.
14. Cruz-Jesus, F., T. Oliveira, and F. Bacao, *Digital divide across the European Union.* Information & Management, 2012. **49**(6): p. 278-291.
15. Stanley, L.D., *Beyond Access: Psychosocial Barriers to Computer Literacy.* Information Society, 2003. **19**(5): p. 407-416.
16. Cullen, R., *Addressing the digital divide.* Online Information Review, 2001. **25**(5): p. 311-320.
17. Antonelli, C., The digital divide: understanding the economics of new information and communication technology in the global economy. Information Economics & Policy, 2003. **15**(2): p. 173.
18. Qingxuan, M. and L. Mingzhi, *New Economy and ICT development in China.* Information Economics & Policy, 2002. **14**(2): p. 275.
19. Menou, M.J. The global digital divide; beyond hICTeria. in Aslib Proceedings. 2001. MCB UP Ltd.
20. Mansell, R., *Constructing the knowledge base for knowledge-driven development.* Journal of Knowledge Management, 2002. **6**(4): p. 317-329.
21. Dewan, S. and J.R. Frederick, *The Digital Divide: Current and Future Research Directions.* Journal of the Association for Information Systems, 2005. **6**(12): p. 298-336.
22. Drouard, J., Costs or gross benefits? - What mainly drives cross-sectional variance in Internet adoption. Information Economics and Policy, 2011. **23**(1): p. 127.
23. Edwards, Y.D., *Looking Beyond the Digital Divide.* Federal Communications Law Journal, 2005. **57**(3): p. 585-592.
24. Moss, J., *'Power and the digital divide'.* Ethics and Information Technology, 2002. **4**(2): p. 159.
25. Mordini, E., et al., *Senior citizens and the ethics of e-inclusion.* Ethics and Information Technology, 2009. **11**(3): p. 203-220.
26. Couldry, N., *New Media for Global Citizens? The Future of the Digital Divide Debate.* Brown Journal of World Affairs, 2007. **14**(1): p. 249-261.
27. Tavani, H.T., *Ethical reflections on the digital divide.* Journal of Information, Communication & Ethics in Society, 2003. **1**(2): p. 99-108.
28. DiMaggio, P., et al., *Social implications of the Internet.* Annual Review of Sociology, 2001. **27**: p. 307-336.
29. Katz, J.E., R.E. Rice, and P. Aspden, *The Internet, 1995-2000: Access, civic involvement, and social interaction.* The American Behavioral Scientist, 2001. **45**(3): p. 405-419.

30. Fuchs, C. and E. Horak, *Africa and the digital divide.* Telematics and Informatics, 2008. **25**(2): p. 99-116.
31. Pick, J.B. and T. Nishida, Digital divides in the world and its regions: A spatial and multivariate analysis of technological utilization. Technological Forecasting and Social Change, 2015. **91**(0): p. 1-17.
32. Cooke, L. and H. Greenwood, "Cleaners don't need computers": bridging the digital divide in the workplace. Aslib Proceedings, 2008. **60**(2): p. 143-157.
33. Pittman, J., Converging instructional technology and critical intercultural pedagogy in teacher education. Multicultural Education & Technology Journal, 2007. **1**(4): p. 200-221.
34. Lee, J.-W., The roles of demographics on the perceptions of electronic commerce adoption. Academy of Marketing Studies Journal, 2010. **14**(1): p. 71-89.
35. Norris, P., Digital Divide: Civic Engagement, Information Poverty, and the Internet Worldwide. 2001: Cambridge University Press.
36. Van Dijk, J. and K. Hacker, *The digital divide as a complex and dynamic phenomenon.* The information society, 2003. **19**(4): p. 315-326.
37. Kyriakidou, V., C. Michalakelis, and T. Sphicopoulos, *Digital divide gap convergence in Europe.* Technology in Society, 2011. **33**(3–4): p. 265-270.
38. Vicente, M.R. and A.J. López, *Assessing the regional digital divide across the European Union-27.* Telecommunications Policy, 2011. **35**(3): p. 220-237.
39. Rao, S.S., *Bridging digital divide: Efforts in India.* Telematics and Informatics, 2005. 22(4): p. 361-375.
40. Schleife, K., What really matters: Regional versus individual determinants of the digital divide in Germany. Research Policy, 2010. **39**(1): p. 173.
41. Douglas, H., *The rural-urban digital divide.* Journalism and Mass Communication Quarterly, 2000. **77**(3): p. 549-560.
42. Novo-Corti, I., L. Varela-Candamio, and M.T. García-Álvarez, *Breaking the walls of social exclusion of women rural by means of ICTs: The case of 'digital divides' in Galician.* Computers in Human Behavior, 2014. **30**(0): p. 497-507.
43. Bach, M.P., J. Zoroja, and V.B. Vukšić, *Determinants of Firms' Digital Divide: A Review of Recent Research.* Procedia Technology, 2013. **9**(0): p. 120-128.
44. Graham, S., Bridging Urban Digital Divides? Urban Polarisation and Information and Communications Technologies (ICTs). Urban Studies (Routledge), 2002. **39**(1): p. 33-56.
45. Peng, G., *CRITICAL MASS, DIFFUSION CHANNELS, AND DIGITAL DIVIDE.* The Journal of Computer Information Systems, 2010. **50**(3): p. 63-71.
46. Burkhard, R.A., Learning from architects: complementary concept mapping approaches. Information Visualization, 2006. **5**(3): p. 225.