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Exploring the Pattern between Education Attendance and Digital Development of Countries

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Abstract

There is a clear belief among academics and policy makers about the importance of ICT for sustainable development and welfare. Thus, all across the world, a variety of strategies to promote the digital development have been proposed and implemented by national and international authorities. Simultaneously, academics have been dedicating their efforts to understand what explains the international digital divide. Within the academia, one can find the education of the individuals as one of the most popular reasons for the digital divide across countries. We tasked ourselves with analyzing this last correlation between digital development and educational attendance of countries and, with data pertaining to 105 countries and we conclude that the correlation is significant and surprisingly high, emphasizing the role of educated individuals in ICT adoption at country level.

Keywords: digital divide; ICT adoption; information society; education; digital development; e-inclusion;

1. Introduction

The importance of information and communication technologies (ICT) for economic and social development of countries is presently well supported by academics and policy-makers [1, 2]. Reputable international organizations often posit that greater adoption and use of ICT will support countries, communities, firms and individuals, to

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engender development and welfare, especially in times of economic crisis as the ones we currently face. The United Nations (UN) (see e.g., [3, 4]), the United States of America (USA) (see e.g., [5-9]), the Organization for Economic Co-operation and Development (OECD) (see e.g., [10-12]), and the European Union (EU) (see e.g., [13-16]) have all deployed some recommendations/strategies to achieve digital development and thus, benefit from the use of ICT. However, as these strategies are been followed mainly by developed countries, they appear now to be contributing to a widening digital divide between developing and developed countries [17]. Even in other countries than the developing ones, there is evidence that the international digital divide is not narrowing, as it was believed to. Within the European Union-27, for example, there is evidence that the most digital developed countries are increasing the adoption and use of ICT at a higher level than those who are not as digital developed, and thus widening the European digital gap [18].

With this work we aim to present a first approach to an exploratory analysis for the commonly referred as important relationship between digital development of countries with the education levels of its inhabitants using for this purpose, data from 105 countries belonging to very different contexts, including 41 from Europe; 24 from Africa; 21 belonging to Asia; 10 from North America and seven from South; and also two from Oceania. In order to measure its digital development we used seven ICT related variables provided by the UN´s International Telecommunications Union (ITU) with the indicator for the tertiary gross enrolment ratio (1) (Educ) provided by the World Bank. This variable is used as a proxy for measuring the education level of individuals within a country. The ICT-related data is concerned to the year of 2011, while the Educ is in respect to 2010, the year immediately before 2011.

2. Measuring the digital development of countries

Measuring and understanding ICT adoption, and thus the digital divide, is a complex and difficult task because these technologies positively influence almost every aspect of our daily actions. Internet browsing, VoIP communications, emailing, access to blogs, multimedia online streaming, social and professional networking, wiki-sites, access to online libraries for research, e-business, and services like e-government, e-health, e-learning, and e-banking are examples of new possibilities that are creating new types of improved communications and interactions, between individuals, firms and public entities. For these reasons ICT are considered as general-purpose technologies (GPT (e.g. the 19th century´s transportation and communications technologies, the Corliss steam engine, the internal combustion engine, or the electric motor), i.e. technological innovations that have the potential to revolutionize most of industries and society sectors.

As previously referred, in order to measure the digital development of countries we used seven variables that together, we believe to cover a wide extent of the ICT adoption and use of a country. The rationale and academic support behind each variable is as follows: One major aspect of the digital development of countries is its ICT infrastructure. Hence, we included the percentage of households with computer (HsPC) [19, 20] , having access to the Internet (HsInt) [18, 21] along with the fixed-telephone (FixTel) [19] and mobile-cellular telephone subscriptions per 100 inhabitants (MobTel) [22]. These four variables provide an important basis to assess the level of ICT adoption and infrastructure. Moreover, considering that the Internet is in constant evolution it is becoming constantly more demanding in terms of resources. Thus, in order to take complete usufruct of it, a broadband connection is necessary, since the majority of websites contain bandwidth-intensive applications such as audio and video streaming, animated content, or interactive applications. We therefore included the fixed (wired)-broadband subscriptions per 100 inhabitants (BroRt) [23, 24], which is a pre-requisite to participate fully in cyberspace. Likewise the fixed (wired) broadband, the mobile (wireless) broadband connection (MobRt) is becoming an important and increasingly popular way to access the Internet in other places than the household or workplace [25]. Finally, as the Internet browsing is perhaps the most general and popular action that individuals can perform through the use of ICT, we have also included the percentage of population regularly using the Internet (IntPop) [18, 21, 24, 26]. The data with its descriptive statistics can be seen in Table 1.

Table 1. Acronyms, descriptions and univariate statistics of variables

Code	Variable	Source	Mean	St. Dev.	Min	Max
HsPC	Percentage of households with computer	ITU	44.47	30.77	1.50	94.50
HsInt	Percentage of households with Internet	ITU	40.52	30.33	1.00	97.20
FixTel	Fixed-telephone subscriptions per 100 inhabitants	ITU	23.00	17.73	0.05	61.06
MobTel	Mobile-cellular telephone subscriptions per 100 inhabitants	ITU	105.02	41.44	4.47	243.50
BroRt	Fixed (wired)-broadband subscriptions per 100 inhabitants	ITU	12.26	11.65	0.00	39.20
MobRt	Active mobile-broadband subscriptions per 100 inhabitants	ITU	22.59	30.22	0.00	216.10
IntPop	Percentage of individuals using the Internet	ITU	44.97	28.11	1.10	95.02

In order to enable us to assess the correlation between the digital developments of countries with the education level of its individuals, we need to transform this seven ICT-related variables into a single measure of the countries´ digital developments. As there is no "right" way to choose one from the seven variables – the choice would be always subjective – we need to calculate a new measure of digital development that include information from all the seven ones presented. To fulfill this aim, we made use of factor analysis. In order to make a correct use of this technique we need to follow a specific methodology. Factor analysis depends on the correlation structure within the original data which makes necessary to confirm that this correlation exists, otherwise this technique may provide meaningless results [27]. Thus, we calculated the correlation matrix of our data (see Table 2). Secondly we needed to confirm the suitability of the data, which is normally made by the Kaiser–Mayer–Olkin (KMO) measure [28]. Finally, as third and last step, we will extract the new factor and perform a reliability analysis of the solution.

Table 2. Correlation matrix

	HsPC	HsInt	FixTel	MobTel	BroRt	MobRt	IntPop
HsPC	1						
HsInt	0.98*	1					
FixTel	0.83*	0.85*	1				
MobTel	0.63*	0.60*	0.52*	1			
BroRt	0.87*	0.90*	0.91*	0.49*	1		
MobRt	0.66*	0.69*	0.56*	0.54*	0.65*	1	
IntPop	0.95*	0.95*	0.83*	0.63*	0.87*	0.63*	1

Note: * - Correlation is significant at the 0.01 level (2-tailed).

The correlation matrix (see Table 2) shows that every correlation is statistically significant at the 0.01 level ($p < 0.01$). Hence we can be sure that all of the variables are measuring the same phenomena – the digital development of countries. To confirm the suitability of the data for factor analysis, the KMO was calculated. It returned the value of 0.86, which expresses a very good suitability. The number of factors to extract depends on the data and context of analysis. From a statistical point of view, there are three criteria - Pearson's, Kaiser's, and the Scree Plot – to decide how many factors should be retained in this analysis. All of them pointed to a one-factor solution. Accordingly, the context of the analysis encourages the one-factor solution. Thus, the statistical criterion coincides with the analysis' framework. As shown in Table 3, the percent of variance retained in this factor is 79%. Hence, we reduced seven ICT-related variables into a single new indicator of digital development of countries, minimizing the original information loss. In order to measure the scale reliability of the extracted factor, Cronbach's Alpha was calculated. It evaluates the internal consistency of the factor within itself and a value over 0.7 is generally considered good [29]. The value returned is 0.92, which confirms the extremely high reliability of our solution, without contradictory values.

Table 3. Results of factor analysis and Cronbach's alpha

Factor Analysis	
Original Variables	Digital Development (DigDev)
HsInt	0.97
HsPC	0.97
IntPop	0.96
BroRt	0.93
FixTel	0.90
MobRt	0.75
MobTel	0.69
KMO	0.86
Variance (%)	79%
Cronbach´s Alpha	0.92

With the previous analysis, we obtained the digital development score (DigDev) for the 105 countries (see Table 4). Macao Special Administrative Region of China is the most digital developed "country", being a very small territory with an astonishing diffusion of ICT. Macao´s government has been deeply dedicated to promote ICT adoption with important measures to provide the territory with ICT (e.g. the price of the local communications is free, with the others like Internet access being very inexpensive, the territory is completely covered by a 3G network, and there are almost no restriction in Internet astonishing, in comparison to the mainland China). On the end of the spectrum, Eritrea is the less digital developed country, which can be explained by the fact that this is one of the poorest of globe, and therefore, its individuals are neither educated nor able to adopt ICT. With the DigDev measure we are now in conditions to analyze the relationship between the digital developments of countries with the education attendance of its citizens.

Table 4. Results of factor analysis and Cronbach's alpha

#	Country		Dig Dev	#	Country		Dig Dev	#	Country		Dig Dev
1	Macao	MAC	2.058	36	Hungary	HUN	0.580	71	Peru	PER	-0.607
2	South Korea	KOR	1.863	37	Cyprus	CYP	0.490	72	Jamaica	JAM	-0.647
3	Luxembourg	LUX	1.753	38	Saudi Arabia	SAU	0.422	73	Thailand	THA	-0.698
4	Sweden	SWE	1.707	39	Belarus	BLR	0.312	74	El Salvador	SLV	-0.727
5	Iceland	ISL	1.703	40	Serbia	SRB	0.292	75	Mongolia	MNG	-0.775
6	Hong Kong	HKG	1.687	41	Brunei	BRN	0.265	76	Indonesia	IDN	-0.793
7	Switzerland	CHE	1.656	42	Uruguay	URY	0.247	77	Paraguay	PRY	-0.797
8	Netherlands	NLD	1.594	43	Macedonia	MKD	0.233	78	Cape Verde	CPV	-0.803
9	United Kingdom	GBR	1.538	44	Montenegro	MNE	0.232	79	Guyana	GUY	-0.848
10	Japan	JPN	1.489	45	Kazakhstan	KAZ	0.220	80	Algeria	DZA	-0.855
11	Finland	FIN	1.461	46	Bulgaria	BGR	0.218	81	Sri Lanka	LKA	-0.898
12	Norway	NOR	1.453	47	Malaysia	MYS	0.206	82	Honduras	HND	-0.931
13	France	FRA	1.367	48	Oman	OMN	0.202	83	Bhutan	BTN	-1.079
14	New Zealand	NZL	1.267	49	Romania	ROU	0.092	84	Zimbabwe	ZWE	-1.101
15	United States	USA	1.254	50	Chile	CHL	0.089	85	Senegal	SEN	-1.135
16	Austria	AUT	1.211	51	Puerto Rico	PRI	0.072	86	Lao	LAO	-1.154
17	Malta	MLT	1.179	52	Argentina	ARG	0.067	87	India	IND	-1.169
18	Ireland	IRL	1.148	53	Lebanon	LBN	0.019	88	Mauritania	MRT	-1.204
19	Australia	AUS	1.133	54	Saint Lucia	LCA	-0.029	89	Angola	AGO	-1.228
20	Belgium	BEL	1.126	55	Moldova	MDA	-0.083	90	Cambodia	KHM	-1.249
21	Estonia	EST	1.058	56	Panama	PAN	-0.088	91	Tanzania	TZA	-1.270
22	Slovenia	SVN	0.922	57	Bosnia Herz.	BIH	-0.113	92	Cameroon	CMR	-1.297
23	Spain	ESP	0.883	58	Turkey	TUR	-0.142	93	Mali	MLI	-1.316

24	Qatar	QAT	0.867	59	Azerbaijan	AZE	-0.147	94	Togo	TGO	-1.318
25	Italy	ITA	0.758	60	Mauritius	MUS	-0.181	95	Rwanda	RWA	-1.331
26	Barbados	BRB	0.731	61	Georgia	GEO	-0.280	96	Comoros	COM	-1.370
27	Czech Rep.	CZE	0.634	62	Ukraine	UKR	-0.307	97	Burkina Faso	BFA	-1.375
28	Portugal	PRT	0.624	63	China	CHN	-0.315	98	Guinea	GIN	-1.410
29	Croatia	HRV	0.613	64	Jordan	JOR	-0.370	99	Madagascar	MDG	-1.411
30	Poland	POL	0.608	65	Mexico	MEX	-0.428	100	Malawi	MWI	-1.416
31	Greece	GRC	0.603	66	Egypt	EGY	-0.439	101	Chad	TCD	-1.438
32	Lithuania	LTU	0.600	67	Colombia	COL	-0.463	102	Cen. African Rep.	CAF	-1.454
33	Antigua Barbuda	ATG	0.598	68	Vietnam	VNM	-0.500	103	Niger	NER	-1.460
34	Slovak Republic	SVK	0.595	69	Tunisia	TUN	-0.574	104	Ethiopia	ETH	-1.483
35	Latvia	LVA	0.590	70	Albania	ALB	-0.595	105	Eritrea	ERI	-1.487

3. The correlation between education attendance and digital development of countries

The education of a country´s individuals is constantly in the literature to be pointed as an important factor for its digital development (see e.g., [18, 30-33]). In the diffusion of innovations theory (DOI) one can find the explanation for this importance. DOI posits that in the adoption of technological innovations, its complexity is a major obstacle for individual and firms, and thus, countries in the aggregate, to adopt new technologies [34]. Thus, the perceived ease of use of a new technology plays an important role in its adoption decision and rate [35]. This fact makes of educational contexts of individuals – and countries – to play an important role, considering that when facing a technical challenge, more educated individuals, are more prone to flexibly and effectively overcome ICT complexity´s obstacles. For this reason, when interacting with an ICT, the those with higher levels of education should perceive as easier to cope with the complexity of ICT-related technologies, hence minimizing the impact of this [36]. Moreover it is also reasonable to hypothesize that more educated individuals are more likely to work in information-intensive industries, thus using more ICT related technologies more often for professional reasons. As Peng et al. [37] demonstrated, individuals who use PC at work or school are more likely to adopt ICT. Thus, the education attendance of individuals within a country (measured by the Educ), serve as proxy for measuring the education level of countries.

The correlation between the DigDev with the Educ is positive (0.79) and statistical significant at 0.01 level (p < 0.01). The visual pattern in the relationship between education and digital development can be seen on Figure 1, which has projected the 105 countries in terms of its DigDev and Educ levels. The horizontal axis presents the Educ of countries, whilst the DigDev is projected on the vertical one. Each axis represents the average values. Hence, the countries within the lower-left quadrant of the plot have below-average Educ and DigDev; the ones in the lower-right present above-levels of Educ and below-average for DigDev; the ones within the upper- left have above-average levels for DigDev and below-average for Educ; whilst countries within the upper-right have above-average levels for both. Additionally, we have drawn a linear regression with the Educ serving as explanatory (independent) variable of the DigDev (dependent one). The slope represents the effect, which indicates that counties with higher Educ present higher levels of DigDev. Globally, the Educ variable explains 63% of the DigDev´s variance. The β parameter indicates that an increase of 1 standard deviation in the Educ variable increases the DigDev value in, approximately, 0.79 units.
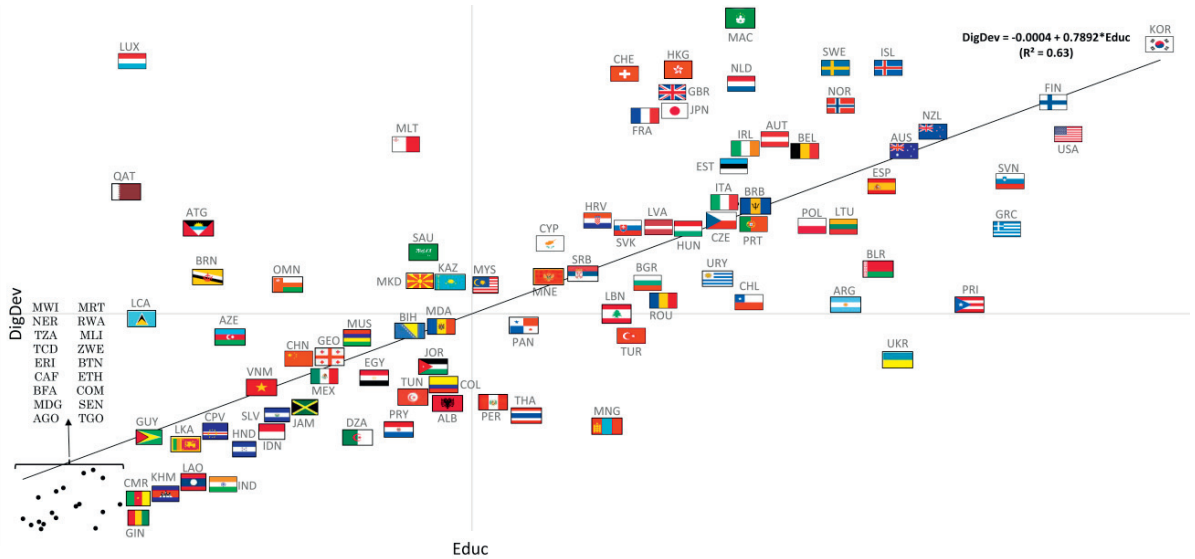
Fig. 1. Countries projections in terms of digital development (vertical) and educational attendance (horizontal).

As one can see, from the analysis of Figure 1 most of the countries follow a linear trend between the Educ and DigDev. South Korea is the country in the best position regarding these two variables together, followed by Finland and USA. In the opposite condition there are a set of countries which present the lowest levels in the two variables, having very similar positions in the plot.

There are some countries with very atypical patterns in terms of Educ and DigDev levels. Luxembourg, Qatar, Malta, and Antigua and Barbuda are three examples. Their DigDev level is far higher than what their Educ would suggest. Luxembourg is the most surprising situation, but the fact is that this country as historically low levels in the Educ levels. This result in particular may be misleading, because of the fact that as Luxembourg is a small territory the majority of its tertiary degrees students are probably in neighbor countries.

4. Conclusions

We measured the digital development of 105 countries from all over the world. As our aim was to analyze the correlation between educational attendances of individuals with the digital development, we assessed the pattern between the score of a factor analysis calculated based on seven ICT-related indicators of countries (DigDev), with the tertiary gross enrolment ratio (Educ). This link between was analyzed using the linear correlations. This correlation is significant and surprisingly high, emphasizing the role of educated individuals in ICT adoption at country level.

Although this research is still in a preliminary stage, the limitations and future work should be highlighted. First, we included seven ICT-related variables to measure the digital development of countries and, therefore, it is likely that some features of the information society are not covered; Moreover, as the analysis was conducted at a country level, domestic/intranational digital gaps are not covered; Finally, and perhaps the most important limitation, which cannot bet neglected, we analyzed the educational attendance of individuals at country level through a proxy variable, the tertiary enrollment ratio. Thus, we have measures of quantity of students proceeding with their studies beyond the secondary levels of studies, towards the achievement of tertiary degrees, but not the education quality per se which may vary across countries. We intend to overcome this limitation by including in the future more variables about the education of countries which will allow us to cover a higher extent of this aspect, similarly to what we have done in measuring ICT adoption.

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