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A new perspective on the ICT Development Index

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Abstract

Information and Communication Technology (ICT) represents an important structural part of modern society; this is why countries strive for constant progress in ICT and why it draws such significant attention. Bearing this in mind, the main goal of this paper is to present an I-distance methodology that holds a new perspective on the measurement of information development, to compare it to the ICT development index (IDI), and to point out improvements that such methodology provides. IDI combines 11 indicators related to three ICT categories: Access, Use and Skills (by weighting the first two by 40 percent and the third by 20 percent). The approach presented in this study uses the same indicators, synthesizing them into one value. Subsequently, which variables are the most relevant for measuring ICT development level of countries are able to be determined. Consequently, the I-distance method provides useful insight into developing countries and ways that enhance their ranking. The results show that the correlation between the I-distance values and IDI values is very strong, $r = 0.961$, $p < 0.01$, which makes I-distance an acceptable measurement method for evaluating countries' ICT development levels.

Keywords

information and communication technology, ICT Development Index, I-distance method, ranking of countries, ICT development structure

The I-distance method creates a measure of information development based on one synthesized indicator.

Introduction

Information and Communication Technology (ICT) has not only become important to modern society, but it has also become a basic structural part of it. ICT has a wide range of economic effects and thus plays an important role in strengthening economic growth and raising socio-economic development (Apostol 2009; Dimelis and Papaioannou 2011). ICT influences the industrial structure of regions and contributes to prosperity on many levels: effecting productivity gains resulting from the development of ICTs, creating new business models and opportunities, creating better educational performance (something positively associated with greater household Internet access), and so on (International Telecommunication Union 2011).

Countries constantly strive to progress in informational development, aiming to build an inclusive information society (Parker 2011; Vicente and Lopez 2011). An increasing number of countries are moving towards more intensive ICT usage. This is due to the real social and economic benefits that only occur through the successful use of ICTs (Gholami et al 2010; Heeks 2010). If an economy is not able to recognize and exploit the advantages of employing and investing in new technologies, economic growth and development will not rise to its full capacity.

The ICT Development Index (IDI) is a benchmarking tool used to monitor information society development worldwide (International Telecommunication

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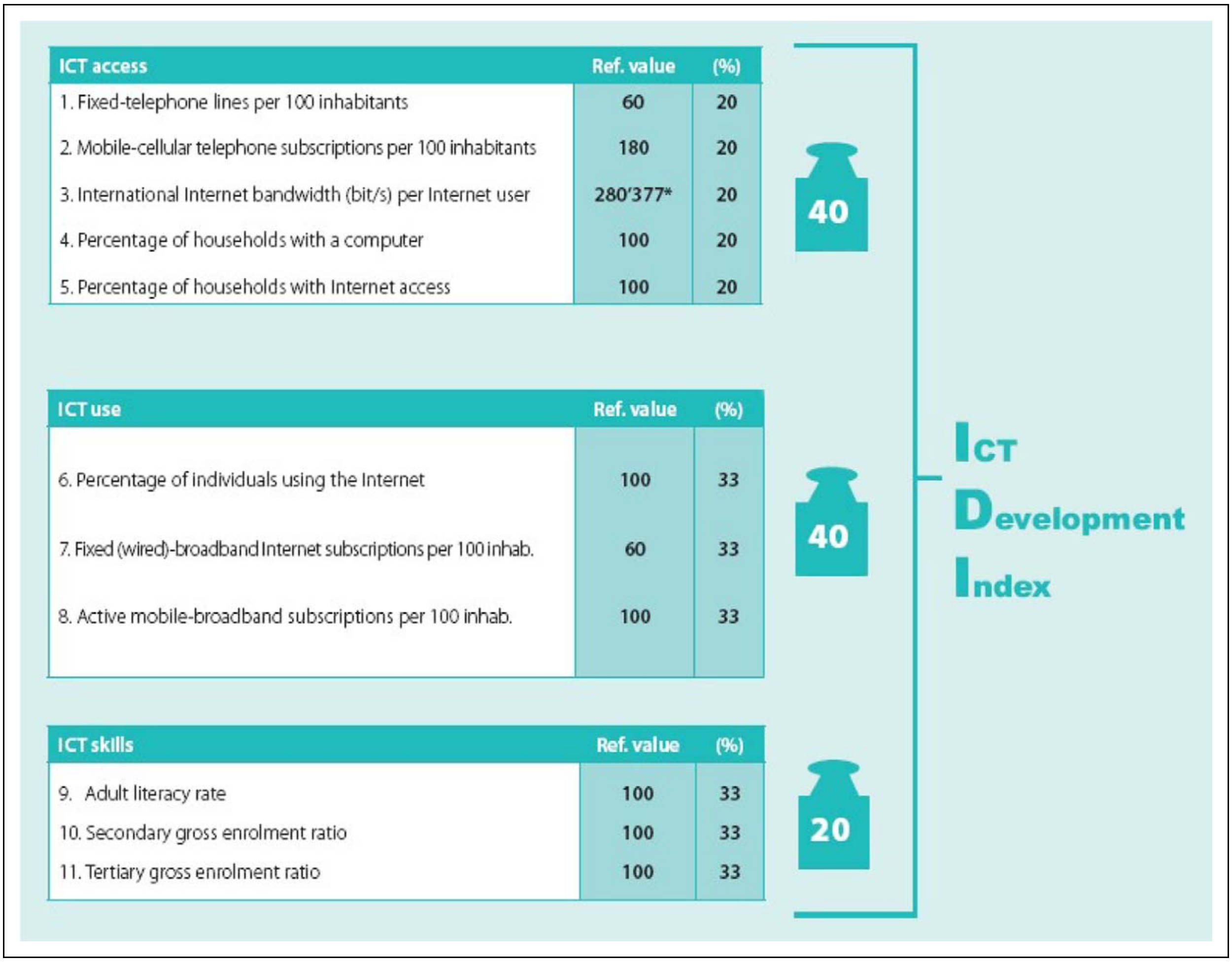

Figure 1. ICT Development Index: Indicators and Weights.

Union 2009, 2011). It combines 11 indicators related to ICT Access, Use and Skills into a single composite index. The main purpose of IDI is to measure the level of ICT development, progress in ICT development, differences between countries with different levels of ICT development, and the development potential of ICTs (International Telecommunication Union 2011).

ICT is composed of three parts (International Telecommunication Union 2011), which include the aforementioned 11 indicators related to ICT Access, Use and Skills:

- **ICT Access** reflects the level of network infrastructure and access to ICTs, capturing its readiness. It includes five infrastructure and access indicators: fixed telephony, mobile telephony, international Internet bandwidth, households with computers, and households with Internet access.
- **ICT Use** reflects the level of use of ICTs in society, capturing its intensity. It includes three ICT intensity and usage indicators: Internet users, fixed broadband, and mobile broadband.
- **ICT Skills** reflects the result/outcome of efficient and effective ICT use, capturing its capability or skills as indispensable input indicators. It includes three proxy indicators: adult literacy, gross secondary and tertiary enrolment (see Figure 1).

The selection of indicators takes the evolution of the information society into account as it goes through its different stages of development, referring to technology convergence and the emergence of new technologies. Therefore, the indicators in each part may change over time to reflect technological developments, since these indicators also strive to recognise the relevance of any particular indicator in its contribution to the main objectives and conceptual framework of the IDI.

Problem definition

The goal of this study has been to rank countries according to their ICT development structure and to compare the results achieved with their ranking based on the ICT development index (IDI). Thereby, a fresh statistical approach to ranking countries is here proposed through the use of the statistical I-distance method (see below), so as to provide a new perspective on the IDI, as it is significantly believed to contribute to its improvement.

The issue at hand is to improve the methodology used to measure a country's development level according to their ICT structure; more specifically, the IDI index methodology has predefined the pattern for measuring a country's ICT structure, which includes ICT Access and ICT Use at 40 percent and ICT Skills at 20 percent. Therefore, IDI is based on a set of input criteria, which are weighted using a defined subjective approach.

Conversely, within the I-distance method, calculations can be made in order to define a set of variables relevant to the analysis (see below). Based on the correlation between the criteria and the I-distance measure, the I-distance method lends a better view on the importance of input criteria, and, consequently, the order of importance of input criteria is able to be determined. In such manner, this method provides an answer to the question: "What variables are more important in measuring the ICT development level of countries?" This fact supersedes the issue of subjectively assigned weights, showing exactly what criteria are most important, and may even dismiss some variables as being redundant.

As indicated above, the methodology of IDI includes 11 indicators, divided into three groups. The main data source used in this study is a set of the aforementioned IDI indicators, the first five of which refer to ICT Access, the next three show ICT Use, and the last three represent ICT Skills. These indicators are (International Telecommunication Union 2011):

- **Fixed Telephone Lines per 100 Inhabitants** – Telephone lines connecting a subscriber's terminal equipment to the public switched telephone network (PSTN) and which have a dedicated port on a telephone exchange, though this may not be the same as an access line or a subscriber. The number of ISDN channels and fixed wireless subscribers are included in this indicator.
- **Mobile Cellular Telephone Subscriptions per 100 Inhabitants** – The number of subscriptions to a public mobile telephone service using cellular technology, which provides access to the Public Switched Telephone Network (PSTN). While post-paid and prepaid subscriptions are included in this indicator, it does not differentiate between subscriptions and subscriber (person). Therein, as one subscriber may have multiple subscriptions, it would be useful to further distinguish between the number of mobile subscriptions and the number of individuals using a mobile phone.
- **International Internet Bandwidth (bit/s) per Internet User** – The capacity that backbone operators provide to carry Internet traffic. This is measured in bits per second per Internet user.
- **The Proportion of Households with a Computer** – A computer refers to a desktop or laptop computer. This does not include equipment that may have some embedded computing abilities, such as mobile cellular phones, personal digital assistants or TV sets.
- **The Proportion of Households with Internet Access at Home** – not assumed to be only via a computer. This may also be by mobile phone, game console, digital TV, etc. Access can be via a fixed or mobile network.
- **Internet Users per 100 Inhabitants** – The increasing use of the Internet through mobile devices is not necessarily reflected in these estimates.
- **Fixed Broadband Internet Subscribers per 100 Inhabitants** – Subscribers to paid, high-speed access to the public Internet (over a TCP/IP connection). Subscribers with access to data communications (including the Internet) via mobile cellular networks are excluded in this indicator.
- **Mobile Broadband Subscriptions per 100 Inhabitants** – Subscriptions to mobile cellular networks with access to data communications at broadband speeds, irrespective of the device used to access the Internet (handheld computer, laptop, or mobile cellular telephone). These services are typically referred to as "3G" or "3.5G".
- **Adult Literacy Rate** – The percentage of the population aged 15 years and over who can both read and write, as well as understand a short simple statement regarding his/her everyday life.
- **Gross Enrolment Ratio (Secondary and Tertiary Level)** – the total enrolment in a specific level of education, regardless of age, expressed as a percentage of the eligible official school-age population that corresponds to the same level of education in a given school-year.

In the study presented here, the I-distance method on these referred indicators has been performed. In addition, the I-distance method is thoroughly elaborated upon below, followed by the results of the proposed method.

The I-distance method

Quite often, the ranking of specific marks is done in such a way that can seriously affect the process of taking exams, sports competitions, UN participation, university ranking, medicine selection and many other areas (Al-Lagilli et al. 2011; Ivanovic 1973; Ivanovic and Fanchette 1973; Jeremic and Radojicic 2010; Jeremic et al. 2011a).

I-distance is a metric distance in an n-dimensional space, which has recently made a significant breakthrough in a number of scientific achievements. It was originally proposed and defined by B. Ivanovic and has appeared in various publications since 1963 (Ivanovic 1973). A notable, striking affirmation of the method has been its use in University ranking (Jeremic et al. 2011a), and evaluating the socio-economic development of countries (Jeremic et al. 2012). Ivanovic devised this method to rank countries according to their level of development based on several indicators. Many socio-economic development indicators were considered, but the problem was how to use all of them in order to calculate a single synthetic indicator, which will thereafter represent the rank.

For a selected set of variables (in this case ICT indicators) chosen to characterize the entities (in this case countries), the square I-distance between the two entities e_r and e_s is defined as:

$$D^2(r,s) = \sum_{i=1}^{k} \frac{d_i^2(r,s)}{\sigma_i^2} \prod_{j=1}^{i-1} (1 - r_{jip}^2)$$

d(r,s) - distance between the values of variable for entities e_r and e_s

σ_i - standard deviation of variable X_i

$r_{ji.p}$ - partial coefficient of the correlation between variables X_i and X_j, excluding X_p $(j<i, p=1,2,\ldots j-1)$

XT=(X1, X2,... Xk) - selected set of variables

The I-distance measurement is based on calculating the mutual distances between the entities being processed, whereupon they are compared to one another, so as to create a rank. In order to rank the entities (in this case, countries), it is necessary to have one entity fixed as a referent in the observing set. The entity with the minimum value for each variable, or a fictive entity, can be set up as the referent one. The ranking of entities in the set is based on the calculated distance from the referent entity (Jeremic et al. 2011c; Knezevic et al. 2012; Radojicic et al. 2012).

The construction of the I-distance is iterative; it is calculated through the following steps (Ivanovic 1973; Jeremic et al. 2011d; Jovanovic et al. 2012):

1. Calculate the value of the discriminate effect of the variable X_2 (the most significant variable which provides the largest amount of information on the phenomena that are to be ranked (Ivanovic 1977; Jeremic et al. 2012b))
2. Add the value of the discriminate effect of X_2 which is not covered by X_1
3. Add the value of the discriminate effect of X_3 which is not covered by X_1 and X_2
4. Repeat the procedure for all variables (Jeremic et al. 2011b 2011e, 2012a).

Results and discussion

The results of the I-distance method, as well as a comparison of the I-distance and the IDI ranking, are shown in Table 1. A total of 111 countries have been included in the analysis. In order to assess the I-distance measurement, a Pearson correlation coefficient between the I-distance values and IDI values has also been calculated. Such correlation is significant at a 0.01 level ($p < 0.01$), and very strong, $r = 0.961$. The fact that the method correlates so closely with the IDI ranking, proves that it is equally suitable and greatly connected to the subject of interest. This validates the I-distance method as an acceptable measurement for evaluating countries in their ICT development level. In addition, this method provides a different perspective on the importance of each input variable, and a correction in the weighting factor for each ICT indicator should therein occur. As for the compared ranking of countries gained by the two methods, a Spearman's rho statistic has additionally been calculated. The correlation is also significant with $r_s = 0.962$, $p < 0.01$.

As can be seen from Table 1, Iceland, Korea, Finland, Sweden and Denmark are the countries that top the I-distance method list. Iceland, which comes in first for the I-distance ranks, takes third place in the IDI rank, and, while Korea tops the IDI rank, it takes second place in the I-distance rank. A very interesting finding is that the first five countries show the same strength in both measurement methods, far above

Table 1. I-distance rank, IDI rank and rank change

Country	I-distance	Rank I-distance	IDI	Rank IDI	Change
Iceland	44.799	1	8.06	3	2
Korea (Rep.)	41.556	2	8.4	1	−1
Finland	41.194	3	7.87	5	2
Sweden	40.971	4	8.23	2	−2
Denmark	40.377	5	7.97	4	−1
Switzerland	37.793	6	7.67	7	1
The Netherlands	37.163	7	7.61	8	1
Australia	36.64	8	7.36	13	5
Norway	35.84	9	7.6	9	0
Luxembourg	35.439	10	7.78	6	−4
United Kingdom	34.774	11	7.6	10	−1
New Zealand	33.623	12	7.43	11	−1
Germany	32.027	13	7.27	14	1
Austria	31.937	14	7.17	15	1
Portugal	31.194	15	6.64	25	10
Belgium	30.889	16	6.83	20	4
France	30.697	17	7.09	16	−1
Singapore	30.514	18	7.08	18	0
Spain	30.162	19	6.73	23	4
Slovenia	29.89	20	6.75	22	2
Lithuania	29.69	21	6.04	33	12
Italy	29.655	22	6.57	26	4
Japan	29.485	23	7.42	12	−11
Israel	29.195	24	6.87	19	−5
United States	28.5	25	7.09	17	−8
Russia	28.299	26	5.38	43	17
Greece	27.754	27	6.28	28	1
Estonia	27.074	28	6.16	31	3
Canada	26.958	29	6.69	24	−5
Montenegro	26.933	30	5.03	47	17
Croatia	26.804	31	6.21	29	−2
Ireland	26.456	32	6.78	21	−11
Saudi Arabia	26.375	33	5.42	42	9
Czech Republic	25.593	34	5.97	35	1
Hungary	25.553	35	6.04	32	−3
Malta	24.662	36	6.43	27	−9
Bulgaria	24.252	37	5.19	45	8
Poland	24.21	38	5.95	36	−2
Panama	23.981	39	4.09	61	22
Latvia	23.356	40	5.9	38	−2
Ukraine	22.663	41	4.34	57	16
Belarus	22.554	42	5.01	48	6
Uruguay	22.186	43	4.93	50	7
United Arab Emirates	22.131	44	6.19	30	−14
Slovak Republic	22.045	45	5.94	37	−8
Argentina	22.003	46	4.64	52	6
Cyprus	21.419	47	5.98	34	−13
Romania	21.166	48	5.2	44	−4
Serbia	20.684	49	5.11	46	−3
Vietnam	20.134	50	3.53	73	23

(continued)

Table 1. (continued)

Country	I-distance	Rank I-distance	IDI	Rank IDI	Change
Oman	19.821	51	4.38	56	5
Bahrain	19.568	52	5.57	41	−11
Kazakhstan	19.494	53	4.02	62	9
Chile	19.279	54	4.65	51	−3
Qatar	18.902	55	5.6	40	−15
Armenia	18.801	56	3.87	66	10
Brunei Darussalam	18.474	57	5.61	39	−18
Seychelles	18.202	58	3.94	65	7
TFYR Macedonia	16.998	59	4.98	49	−10
Venezuela	16.819	60	4.11	60	0
Azerbaijan	15.882	61	3.78	68	7
Mongolia	15.484	62	3.41	77	15
Moldova	15.413	63	4.47	53	−10
Georgia	15.397	64	3.65	71	7
Bosnia & Herzegovina	14.921	65	4.31	58	−7
Brazil	14.872	66	4.22	59	−7
Malaysia	14.574	67	4.45	54	−13
Kyrgyzstan	14.495	68	2.84	89	21
Jordan	14.111	69	3.83	67	−2
Uzbekistan	13.889	70	2.55	96	26
Colombia	13.706	71	3.75	69	−2
Fiji	13.627	72	3.16	84	12
Costa Rica	13.259	73	3.99	64	−9
Mexico	12.813	74	3.75	70	−4
Turkey	12.794	75	4.42	55	−20
Thailand	12.753	76	3.3	79	3
Peru	12.608	77	3.52	74	−3
Jamaica	12.594	78	3.41	76	−2
Mauritius	11.895	79	4	63	−16
South Africa	11.852	80	3	86	6
Philippines	11.8	81	3.22	82	1
Tunisia	11.059	82	3.43	75	−7
Botswana	11.023	83	2.59	95	12
Indonesia	10.899	84	2.83	91	7
Ecuador	10.869	85	3.37	78	−7
China	10.833	86	3.55	72	−14
El Salvador	10.823	87	2.89	87	0
Paraguay	10.711	88	2.87	88	0
Honduras	10.576	89	2.72	93	4
Sri Lanka	10.394	90	2.79	92	2
The Dominican Rep.	10.138	91	3.21	83	−8
Bolivia	9.817	92	2.83	90	−2
Guatemala	8.792	93	2.65	94	1
Namibia	7.169	94	2.36	97	3
Syria	7.063	95	3.05	85	−10
Egypt	6.455	96	3.28	81	−15
Zimbabwe	6.366	97	1.81	106	9
Nicaragua	5.275	98	2.31	98	0
Morocco	4.9	99	3.29	80	−19

(continued)

Table 1. (continued)

Country	I-distance	Rank I-distance	IDI	Rank IDI	Change
Cambodia	3.492	100	1.99	100	0
Lao PER	3.062	101	1.9	103	2
Ghana	3.037	102	1.9	102	0
India	2.664	103	2.01	99	−4
Bhutan	1.85	104	1.93	101	−3
Mauritania	1.623	105	1.58	109	4
Uganda	1.595	106	1.49	110	4
Angola	1.471	107	1.58	108	1
Nigeria	1.069	108	1.85	104	−4
Senegal	1.055	109	1.78	107	−2
Pakistan	0.861	110	1.83	105	−5
Mozambique	0.17	111	1.3	111	0

other countries. This is easily explained, since eight of the top ten are highly developed European countries, and Europe is the world's leading region in ICT infrastructure and services. This comes as no surprise, as the, Old Continent' has a population that is much more homogenous and its constant commitment to ICT values is easily understood. All of these European countries have a large percentage of Internet users; computers and telephone lines there are practically universally accessible as well. These are the exact factors that result in European countries attaining higher positions. Similarly, both Korea and Australia are developed countries that are members of the Organization for Economic Co-operation and Development (OECD) (Dobrota et al. 2011; World Bank 2011).

Angola, Nigeria, Senegal, Pakistan and Mozambique come in at the bottom of the I-distance rank. The situation in these countries is very unlike those that top the rank. The percentage of households with a computer, let alone Internet access, is extremely low. The same is true for the percentage of telephone lines. For instance, in Mozambique there are only 4.2 Internet users per 100 people (95 percent for Iceland); thus, only a small part of this country is embracing the development of ICT. Overall, most countries at the bottom of the rank are low-income countries and are from the group of Least Developed Countries (LDCs).

The differences between the IDI and I-distance ranks are also shown in Table 1. It is interesting to note that the difference between these ranks is less than 10 in all of the 82 cases (73.87 percent of total). For 21.62 percent of them, the difference is among 10 and 20. Only in 4.51 percent is there a difference greater than 20. Great differences appear for the countries of Panama, Vietnam, Kyrgyzstan and Uzbekistan. The largest difference in rank is in the case of Uzbekistan, which is ranked as being in the 70th place by I-distance, but in the 96th by IDI (a 26 rank difference).

If the issue were to be observed in regard to Serbia, it would be found that this country is ranked in the middle, by both the I-distance and IDI rankings (with a difference in rank of only 3). In Serbia, 50.9 per cent of households own a computer and 40.2 per cent have an Internet connection. This is rather below those countries which top the ranking list, where the percentage of households owning a computer and having an Internet connection increases to 93 percent and 92 percent respectively. Serbia may score high enough to be ranked in the middle, but it is quite obvious that it is still far off from meeting European Union development goals. ICT variables clearly reflect Serbia's current situation, as 43.7 percent of population has never used computer, while the European average is 26 percent. Likewise, 54.1 percent have never used the Internet, while the European average is 30 percent (Nita 2011; RZS 2011). There are certain differences in Serbia throughout its regions in terms of ICT usage and development. For instance, Belgrade and northern Serbia (the province of Vojvodina) are significantly better than southern Serbia. These regions are more aware of the importance of ICT, and they consequently more readily invest in this area, as prosperity and economic benefit which are to be brought by ICT development. This is also evident concerning the development of Vojvodina's ICT Cluster, which is the strongest in its field in Serbia, as well as the development of an IT Park in the town of Indjija (also in Vojvodina).

Table 2. Variable importance as measured by correlation with the I-distance

Variables	Correlation with the I-distance
Fixed (wired)-broadband Internet subscriptions per 100 inhabitants	0.837**
Fixed-telephone lines per 100 inhabitants	0.823**
Percentage of households with Internet access	0.798**
Percentage of individuals using the Internet	0.792**
Percentage of households with a computer	0.788**
International Internet bandwidth (bit/s) per Internet user	0.782**
Active mobile-broadband subscriptions per 100 inhabitants	0.766**
Tertiary gross enrolment ratio	0.682**
Mobile-cellular telephone subscriptions per 100 inhabitants	0.656**
Adult literacy rate	0.650**
Secondary gross enrolment ratio	0.621**

Note: $^{**}p < 0.01$.

As has been previously implied, one of the main objectives this paper is to present the relevance of ICT indicators. Namely, the I-distance method uses the same indicators, but puts them into a specific order of importance. This allows for a better understanding of the ranking results of the I-distance method, as well as for a better comprehension of the differences between the I-distance and IDI results. In that, it is essential to establish an order of importance for the indicators since it provides an answer to the question: "What are the variables that are the most relevant for measuring the ICT development level of countries?" Accordingly, a Pearson correlation coefficient of each variable with the I-distance value has been calculated as to determine the significance of input variables. These correlations are presented in Table 2.

The results show that all the variables are significantly correlated to the I-distance measurement values. The most statistically significant variable for determining ICT development structure appears to be *Fixed (wired)-broadband Internet subscriptions per 100 inhabitants*, where $r = 0.837$, $p<0.01$. This is not surprising, since previous research has shown a relatively high awareness of cable modem and DSL availability (Savage and Waldman 2005). In addition, much previous research has emphasized Internet connections as being quite significant in determining a country's development level. Very high relevant positions are taken by the three important variables: *Percentage of households with Internet access*, *Percentage of individuals using the Internet* and *Percentage of households with a computer*. It is evident that these variables most certainly signify not only a country's ICT development structure, but also are important indicators of social and economic benefit.

It is essential for lower-ranked countries to improve these most significant ICT development indicators in order to improve their overall position in the ranking process. This is also very important for Serbia in order to increase its own prosperity and improve its own general progress. For example, *Fixed (wired)-broadband Internet subscriptions per 100 inhabitants* in Serbia is only 8.5, which is far less than the same variable for Iceland or in Korea, which amounts to approximately 35 per 100 inhabitants. Similarly, about 40.2 per cent of Serbian households have Internet access, and 40.9 per cent of individuals use the Internet; whereas in Iceland and in Korea, these percentages are greater than 90 percent.

Conclusion

There is a constant tendency of economies towards the expansion of their ICT and towards an overall transition into the global information society (Parasyuk 2010; Pyrig 2010). The main goal of this paper has been to present a new perspective on the measurement of countries' informational development, as implemented by using the I-distance method, and to compare it with the ICT development index.

Firstly, through the use of the I-distance method, this paper has proposed a fresh approach to the evaluation of countries' ICT development. Moreover, it is one that uses the same 11 indicators related to the three ICT categories: Access, Use and Skills, and yet unlike the IDI that weighs the first two categories by 40 percent and the third by 20 percent, I-distance can arrange them according to a specific order of importance. This reveals which variables are most relevant in measuring the ICT development level of countries, provides useful insight into developing countries, and suggests a way to enhance their ranking by supplying a comprehensive international performance evaluation based on quantitative indicators, benchmarks, and by identifying areas of high and low growth in ICT-related development. The main advantages of the method are reflected in the fact that the recent expansion of this method is noticeable in a number of studies where the key to ranking entities is the use of a large number of criteria. The advantage is therein presented that the I-distance method creates one synthesized unbiased indicator that incorporates many criteria into one criterion. Certainly, this is one of the main contributions of this paper. In addition, I-distance proposes a different approach in determining the weighting factor. Compared to IDI methodology, the I-distance approach does not rely on subjectively chosen weights; rather, it arranges criteria in a specific order. In particular, it defines the most significant variable which provides the largest amount of information on the phenomena that are to be ranked and consequently all of the other variables that are to follow.

Secondly, I-distance has proven to be an exceptional measurement tool, which is further confirmed by the results of the Pearson correlation coefficient between the I-distance values and the IDI values. The correlation is very strong, $r = 0.961$, $p < 0.01$. Accordingly, the differences between the ranks are found to be less than 10 in 73.87 percent, 10 to 20 in 21.62 percent of cases, and only in 4.51 percent is the difference greater than 20.

Thirdly, the results presented in this study clearly show that Serbia has a long road ahead of it in order to achieve European Union development goals and become a full member of the EU. The ICT development indicators are significantly lower than EU standards and Serbia must definitely focus on improving them. Although ICT was among the most vibrant and fastest growing sectors in Serbia, experiencing double-digit annual growth in the years prior to the global recession, the economic crisis hit Serbia severely, producing significant negative consequences to the ICT industry as well. This resulted in a steep decline: in 2009 alone, the IT market in Serbia fell by 22.20 percent (Mijacic et al. 2011). However, it is also worth mentioning that Serbia started building an IT Park in the town of Indjija, which is planned to be finished by 2013 and shall be spread over 250,000 m^2, making it Europe's largest. The Park will provide housing to IT services and technology providers, employing up to 25,000 individuals.

Finally, a new approach to evaluating the ICT development index has been presented in this paper. This novel approach is not based on arbitrarily chosen weighting factors, and it may be able to significantly contribute to emerging research in the field of ICT development structure. In brief, the paper presented here has indicated that the I-distance method creates one synthesized unbiased indicator that incorporates many ICT indicators into one indicator.

References

Al-Lagilli S, Jeremic V, Seke K, Jeremic D and Radojicic Z (2011) Evaluating the health of nations: a Libyan perspective. *Libyan Journal of Medicine* 6: 6021. doi: 10.3402/ljm.v6i0.6021.

Apostol DM (2009) Knowledge, education and technological progress in the new economy. *Metalurgia International* 14 (SI5): 78–81.

Dimelis SP and Papaioannou SK (2011) ICT growth effects at the industry level: A comparison between the US and the EU. *Information Economics and Policy* 23(1): 37–50.

Dobrota M, Milenkovic N, Jeremic V and Djokovic A (2011). Neural networks in determining the level of countries' economic development. In*: Proceedings of the VIII Congress of Entrepreneurs and Scientists*, Belgrade, Serbia, 01–02 November 2011, pp. 547–553. Belgrade: FON.

Gholami R, Higon DA, Hanafizadeh P and Emrouznejad A (2010) Is ICT the key to development? *Journal of Global Information Management* 18(1): 66–83.

Heeks R (2010) Do information and communication technologies (ICTs) contribute to development? *Journal of International Development* 22: 625–640.

International Telecommunication Union (2009). *Measuring the Information Society – The ICT Development Index 2009*, ITU, Geneva.

International Telecommunication Union (2011) *Measuring the Information Society 2011*. Available at: http://www.itu.int/ITU-D/ict/publications/idi/2011/ (accessed 7 November 2011)

Ivanovic B (1973). *A method of establishing a list of development indicators*. Paris: UNESCO.

Ivanovic B (1977). *Classification theory*. Belgrade: Institute for Industrial Economic.

Ivanovic B and Fanchette S (1973). *Grouping and ranking of 30 countries of Sub-Saharan Africa, Two distance-based methods compared*. Paris: UNESCO.

Jeremic V and Radojicic Z (2010) A new approach in the evaluation of team chess championships rankings. *Journal of Quantitative Analysis in Sports* 6(3): Article 7. doi: 10.2202/1559–0410.1257

Jeremic V, Bulajic M, Martic M and Radojicic Z (2011a) A fresh approach to evaluating the academic ranking of world universities. *Scientometrics* 87(3): 587–596.

Jeremic V, Isljamovic S, Petrovic N, Radojicic Z, Markovic A and Bulajic M (2011b) Human development index and sustainability: What's the correlation? *Metalurgia International* 16(7): 63–67.

Jeremic V, Vukmirovic D, Radojicic Z and Djokovic A (2011c) Towards a framework for evaluating ICT infrastructure of countries: a Serbian perspective. *Metalurgia International* 16(9): 15–18.

Jeremic V, Markovic A and Radojicic Z (2011d) ICT as crucial component of socio-economic development. *Management* 16(60): 5–9.

Jeremic V, Seke K, Radojicic Z, Jeremic D, Markovic A, Slovic D and Aleksic A (2011e) Measuring health of countries: a novel approach. *HealthMED* 5(6): 1762–1766.

Jeremic V, Slovic D and Radojicic Z (2012a) Measuring human capital: a statistical approach. *Actual Problems of Economics* 5: (In press).

Jeremic V, Bulajic M, Martic M, Markovic A, Savic G, Jeremic D and Radojicic Z (2012b). An evaluation of European countries health systems through distance based analysis. *Hippokratia* 16(2): 175–179.

Jovanovic M, Jeremic V, Savic G, Bulajic M and Martic M (2012). How does the normalization of data affects the ARWU ranking? *Scientometrics* Online First, doi: 10.1007/s11192-012-0674-0.

Knezevic S, Jeremic V, Zarkic-Joksimovic N and Bulajic M (2012) Evaluating the Serbian banking sector: a statistical approach. *Metalurgia International* 17(1): 171–174.

Mijacic D, Kappenmann J and Sredojevic M (2011) *ICT in Serbia: at a glance*. GIZ, ACCESS and Vojvodina ICT Cluster. Available at: http://www.vojvodinaictcluster.org/Images/ICT_in_Serbia_At_a_Glance_2011.pdf (accessed 1 November 2011)

Nita V (2011) An extended approach to e-inclusion and its implications for Romania. *Romanian Journal of European Affairs* 11(1): 63–80.

Parasyuk IV (2010) Information models in evaluation of economic development of a region. *Actual Problems of Economics* 112: 231–239.

Parker S (2011) The digital divide is still with us. *Information Development* 27: 84–84.

Pyrig DZ (2010) Application of information technologies in management of innovative potential development. *Actual Problems of Economics* 107: 135–142.

Radojicic Z, Isljamovic S, Petrovic N and Jeremic V (2012) A novel approach to evaluating sustainable development. *Problemy Ekorozwoju – Problems of Sustainable Development* 7(1): 81–85.

RZS (2011) Serbian Republic Bureau of Statistics. Available at: http://webrzs.stat.gov.rs/WebSite/Public/PageView.aspx?pKey=205 (accessed 15 September 2011)

Savage SJ and Waldman D (2005) Broadband Internet access, awareness, and use: Analysis of United States household data. *Telecommunications Policy* 29(8): 615–633.

Vicente MR and Lopez AJ (2011) Assessing the regional digital divide across the European Union-27. *Telecommunications Policy* 35: 220–237.

World Bank (2011). *List of economies*. Available at: http://siteresources.worldbank.org/DATASTATISTICS/Resources/CLASS.XLS (accessed 18 November 2011)

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