Some Aspects of ICT Measurement: Comparative Analysis of E-Indexes

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Abstract. There are more than twenty widely used e-indexes which are used to measure ICT Adoption all over the world. It might be a problem to choose ones to analyze the ICT dynamics or to compare the levels of ICT development in different regions of the world. So first the most common e-indexes were reviewed. Then the comparative analysis of the e-indexes structure has been done. The coherence of the e-indexes has been estimated using pair and rank correlation. The 'core' of the consolidated e-indexes was defined and the intersections of some e-indexes and the 'core' have been analyzed.

Keywords: E-Index, Pair and Rank Correlation, 'Core' of E-Indexes

1 Introduction

The composite e-indexes were developed to measure the levels of ICT Adopting in different countries all over the world. Nowadays there are more than twenty widely used e-indexes, among them the most popular are: Information Society Index (Dergachev, 2014), E-Readiness Index (Belova, 2011), Knowledge Economy Index (Batrakova, 2012), E-Government Development Index (Department of Economic and Social Affairs, United Nations, 2014), ICT Development Index (International Telecommunication Union, 2014), Digital Access Index (Market Information and Statistics Unit, 2003), Technology Achievement Index (Desai, 2002), Networked Readiness Index (Networked Readiness Index, 2015, Mikova, 2011, World Economic Forum, 2014), Digital Opportunity Index (International Telecommunication Union, 2010), ICT Opportunity Index (Nikitenkova, 2012), ICT Diffusion Index (Nikitenkova, 2012), Global Competitiveness Index (Global Competitiveness Index, 2015), Global Innovation Index (Cornell University, INSEAD, WIPO, 2014), Infostates (Sciadas, 2003).

The measurement of the ICT Adopting requires an actual data and comparable time series. But a lot of the e-indexes were estimated only a few times, some of them are difficult to verify.

So the aim of the study is comparative analysis of the e-indexes, assessment of their coherence, and determination key indicators of ICT Adopting.

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2 E-indexes Structure Analysis

Let's consider fourteen mentioned above e-indexes and carry out the comparative analysis of their structure. Eighty percent of e-indexes listed in Table 1 are calculated for more than 140 countries, although some of them (eg, ISI, ERI, and TAI) are less common.

Table 1. The list of the most widely used E-Indexes

Short name	Full name	Author	First publication	Number of countries
ISI	Information Society Index	IDC	1997	53
ERI	E-Readiness Index	EIU	2000	70
KEI	Knowledge Economy Index	WEF	2005	140
EGDI	E-Government Development Index	UNPAP	2002	182
IDI	ICT Development Index	ITU	2002	154
DAI	Digital Access Index	ITU	2003	178
TAI	Technology Achievement Index	UNDP	2001	72
NRI	Networked Readiness Index	WEF	2002	148
DOI	Digital Opportunity Index	ITU	2005	181
ICT-OI	ICT Opportunity Index	ITU	2005	183
ICT-DI	ICT Diffusion Index	UNCTAD	2006	180
GII	Global Innovation Index	INSEAD	2007	143
GCI	The Global Competitiveness Index	WEF	2004	144
IS	Infostates	ORBICOM	2003	183

Analysis of Fig. 1 shows that 80% of indexes are based on the 15 partial indicators as maximum (the partial indicators are got in the sub-indices which are grouped into final indexes).

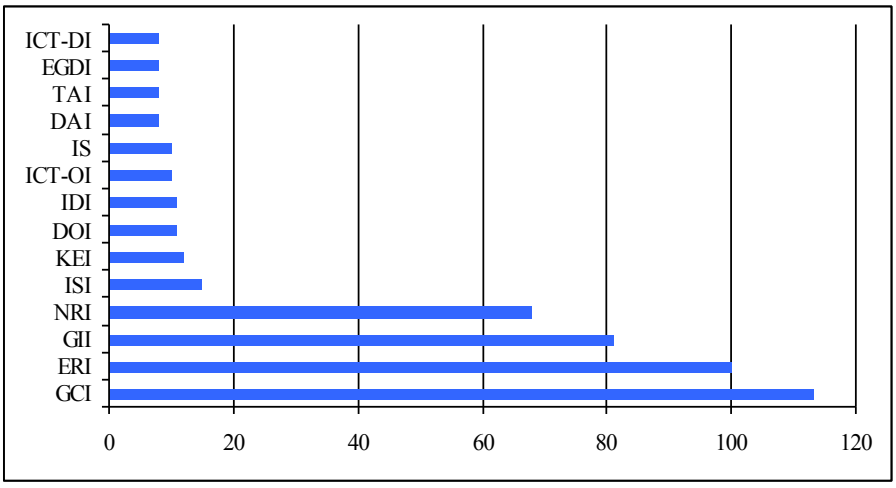

Fig. 1. The e-indexes ranked by the number of partial indicators

The simplicity of the e-indexes structure provides ease of their interpretation, at the same time the multidimensionality let to analyze a wide range of issues related to ICT Adopting.

The maximum number of partial indicators (113) has Global Competitiveness Index. E-Readiness Index contains more than one hundred partial indicators, but a complete estimation methodology of this index is not public. Also, a large number of indicators are included to Global Innovation Index – 81, and Networked Readiness Index – 68.

The minimum number of indicators among the indexes is eight, it consist four indexes: DAI, TAI, EGDI and ICT-DI. Only four indexes include greater than 60 indicators, the rest ten consist less than 30.

Considering the indexes in terms of their quality structure (Fig. 2), it should be noted that most of them are based on the hard data (statistical data from official sources, which have been obtained empirically and can be tested). However, there are a number of indexes with a lot of soft data (information obtained from statistical surveys and expert assessments, conducted by the authors of studies).

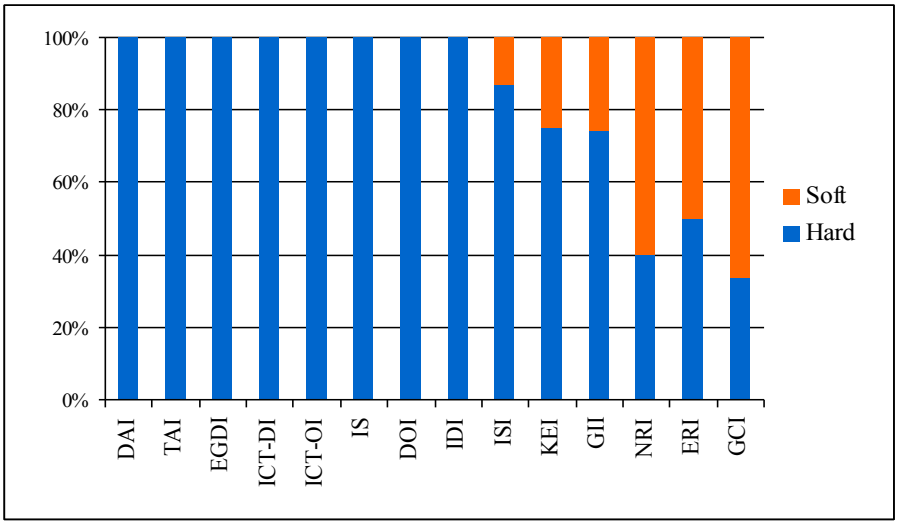

Fig. 2. The e-indexes ranked by hard and soft data in their structure

The analysis shows that eight of 14 indexes use only hard data (ICT-DI, EGDI, TAI, DAI, IS, ICT-OI, IDI, DOI), and only three indexes consist mainly soft data (NRI – 60.29%, ERI – 50% and GCI – 66.37%). Although the calculating methodologies of NRI (which is includes 68 partial indicators) and of GCI (which is includes 113 partial indicators) have a complete list of partial indicators with the references, but the developers do not give an access to own statistical surveys, and it is impossible to repeat their studies. The calculating methodology of ERI (which is includes 100 partial indicators) is not given in full, which also makes verifying the data impossible.

It is interesting to consider the share of ICT indicators in the total number of partial indicators (Fig. 3). At the early stages of ICT Adopting, the main focus was on the information infrastructure. Nowadays the number of indicators that are not directly related to the dissemination and use of ICT has increased because of the multidimensionality and complexity of the issues related to ICT Adopting.

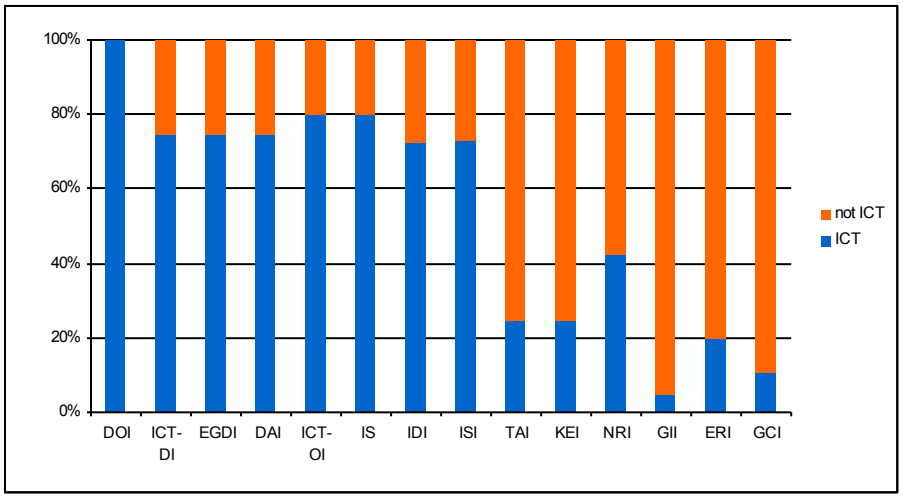

Fig. 3. The e-indexes by ICT and not ICT indicators in their structure

Only one (DOI) of the 14 analyzed composite e-indexes uses solely ICT-related partial indicators, the others combine them with socio-economic indicators. Six of e-indexes (GII, GCI, ERI, KEI, TAI, and NRI) contain more than half of indicators which are not related to ICT directly. This fact can be justified by the assumption that the success of ICT Adopting depends on indirect characteristics (eg, education) more than on the technological parameters.

3 E-indexes coherence

The next stage of the study was the coherence analysis of the e-indexes. Some of fourteen indexes mentioned above were evaluated only a few times. Also an important factor was the availability of data in the public domain. Therefore, only six indexes (KEI, IDI, EGDI, GII, NRI, and GCI) were selected for the further studies.

The paired correlation coefficients for the 96 countries in 2013 were evaluated (see Table 2). The analysis of Table 2 shows that there is a strong probability of linear dependence between the e-indexes (the confidence level is not less than 95%).

Table 2. The paired correlation coefficients

Indexes	KEI	GII	IDI	EGDI	NRI	GCI
KEI	1	0,92	0,92	0,92	0,90	0,81
GII	#	1	0,87	0,86	0,94	0,88
IDI	#	#	1	0,91	0,88	0,81
EGDI	#	#	#	1	0,91	0,82
NRI	#	#	#	#	1	0,92
GCI	#	#	#	#	#	1

Also the countries were ranked according to these six e-indexes (a fragment is shown in the Table 3).

Table 3. The list of countries ranked by e-indexes

Countries	**Rank by KEI**	**Rank by GII**	**Rank by IDI**	**Rank by EGDI**	**Rank by NRI**	**Rank by GCI**
Korea	26	18	1	1	9	22.5
Sweden	1	2	2	13	2	8
Denmark	3	6	3	15	7	10.5
Iceland	15	15	4	18	14	27
Finland	2	3	5	9	1	4
Netherlands	4.5	5	6	4	3	4
Japan	20	22	7.5	5	18	4
...	…	…	…	…	…	…
Ukraine	48	51	50	66	61	65.5
...	…	…	…	…	…	…
Ethiopia	96	95	94	91	92	86.5
Burkina Faso	90	91.5	95	95	93	95.5

The coherence analysis using the Kendall's concordance coefficient shows that the ranking of countries based on the values of six e-indexes can be considered highly consistent with a confidence level of 99% (coefficient of concordance is 0.91, the empirical value of χ^2 is 517, it exceeds the critical value $\chi^2_{crit} = 130$).

4 E-indexes 'Core' Analysis

Let's consider in detail the structure of the e-indexes and analyze partial indicators in terms of application frequency (Table 4).

The indicators, which application frequency exceeds 50%, will be named the 'core' of composite indexes (see the first eight partial indicators in the Table 4).

Another six partial indicators form the first layer of the 'shell core', their application frequency varies from 30% to 50% (see the next six partial indicators in the Table 4). The rest 12 indicators, which application frequency varies from 15% to 29%, can be classified as the second layer of the 'shell core', as many authors believe

that they are closely related to the level of ICT Adopting (eg, the difficulties in starting a new business are estimated in GCI, NRI, GII and ERI).

Besides shown in Table 4, there is a large number of indicators (let's call them 'cloud') that occurred in the calculations no more than once. For example, GII uses the number of Wikipedia articles, YouTube videos, and movies per capita; GCI considers the level of the nation's health, its impact on business.

Table 4. The 'core' and 'shell core' of the partial indicators

Partial indicators	Application frequency	Class
Number of cellular subscribers (per 100 people)	85%	'core'
Higher education enrollment	85%	
Internet users (per 100 people)	77%	
Fixed telephone lines (per 100 people)	69%	
Secondary school enrollment	69%	
Users of fixed broadband internet (per 100 people)	54%	
Users of mobile broadband Internet (per 100 people).	54%	
The index of adult literacy	54%	
International Internet traffic (Kbit/s per capita)	46%	the first layer of the 'shell core'
Primary school enrollment	46%	
Expected years of schooling	46%	
Applications for patents residents	38%	
Secure Internet servers (per 1 million people)	31%	
The proportion of households with a computer	31%	
The proportion of households with Internet access	23%	the second layer of the 'shell core'
Applications for patents of non-residents	23%	
Payments for licenses and copyright	23%	
Number of PC (per 100 people).	23%	
GDP per capita (US dollars)	15%	
Articles in scientific and technical journals	15%	
The number of households with TV (per 100 households)	15%	
International outgoing telephone traffic (min. per person).	15%	
Percentage of population with coverage telephone	15%	
The time required to start a business (days)	15%	
The number of procedures required to start a business	15%	
Severance pay for redundancy	15%	

As GII, NRI, GCI consist more than 60% of indirectly related to the ICT indicators; and NRI, GCI contain more than 60% of unverifiable data (see part 2 of the study), we choose two e-indexes (IDI and EGDI) from six which coherence was analyzed (see part 3 of the study) to check their intersection with the 'core' of e-indexes (Table 5).

Table 5 shows that the partial indicators of IDI and EGDI overlap substantially, but the IDI strongly intersects with the 'core' of e-indexes (by 73% compared to 55% for EGDI). So we would recommend using IDI to analyze ICT Adopting in details.

Table 5. The structure of IDI and EGDI

EGDI	IDI
Telecommunication Infrastructure sub-index	Access sub-index
– individuals using the Internet (% population)*	– fixed-telephone subscriptions/100 inhabitants*
– fixed-telephone subscriptions (per 100)*	– mobile-cellular telephone subscriptions/100 inhabitants*
– mobile-cellular subscriptions (per 100)*	– international Internet bandwidth (bits/s) per user
– fixed (wired)-broadband subscriptions (per 100)*	– percentage of households with a computer
– wireless broadband subscriptions (per 100)*	– percentage of households with Internet access
Online Service sub-index	Use sub-index
– emerging information services	– percentage of individuals using the Internet*
– enhanced information services	– fixed (wired)-broadband subscriptions per 100 inhabitants*
– transactional services	– wireless broadband subscriptions per 100 inhabitants*
– connected services	
Human Capital sub-index	Skills sub-index
– adult literacy*	– adult literacy rate*
– gross enrolment ratio	– gross enrollment ratio secondary level*
– expected years of schooling	– gross enrollment ratio tertiary level*
– mean years of schooling	

* Partial indicator which are belong to the 'core' of e-indexes

5 Conclusions

Comparative analysis of fourteen most popular e-indexes has allowed allocating the group of partial indicators (the 'core' of composite e-index), which application frequency was higher than 50%. The 'core' includes: indicator of literacy, enrollment in higher and secondary education, the number of mobile and fixed broadband users, and the number of cellular subscribers, internet users and fixed-line telephone.

The strong requirements to e-indexes, such as the availability of data for its assessment in the public domain, the use of reliable information for calculations; the prevailing role of the indicators that are directly related to the ICT; and the results of 'core' analysis allow us to recommended ICT Development index to monitoring of ICT Adopting.

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