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UKRAINE IN THE INFORMATION AND COMMUNICATION TECHNOLOGY DEVELOPMENT RANKING. II

The paper considers the level and evolution of information and communication technology developments in Ukraine and its experience relative to other Eastern European and post-Soviet countries based on the Information and Communication Technology Development Index over 2002–2017. Also modeling of the indicators characterising the development of information and telecommunication technologies in Ukraine is presented. The GMDH models are built to forecast when the percentage of individuals using the Internet in Ukraine will achieve the same level as Kazakhstan and Belarus. This models shown that Ukraine will be on the point of overtaking Belarus in the end of the forecasted period but won't reach the level of Kazakhstan because of much more extensive development of ICTs there.

Keywords: *Information and Communication Technology Development Index, digital divide, global development indices, Digital Agenda of Ukraine.*

Introduction

This research continues the study of information and communication technology development in Ukraine in comparison with other Eastern European and post-Soviet countries. The first part of the article [10] analyzes the potential of Ukraine to achieve the goals defined in the “Digital Agenda of Ukraine 2020” based on its progress in the Information and Communication Technology Development Index (ICT Development Index, or IDI) over 2002–2017. The second part of the article focuses on the analysis of evolution of the sub-indices and their components and the key features of information and communication technology development in Ukraine. Modeling of the indicators describing the ICT development in Ukraine will be done in order to establish the relationship among these indicators.

Ukraine In the IDI Sub-indices

The sub-indices of the IDI and their change between the first and the last studies should be analyzed in order to define a reason of such a regress for Ukraine. They are presented in Table 3.

As the Table 3 shows Ukraine is highly ranked in the Skills sub index in both 2002 and 2017 – 21 and 15 respectively. In 2002 Ukraine was only behind Poland (17) and Russia (20). In 2017 Ukraine was on the 3 position again – this time behind Belarus (5) and Russia (13). This sub-index seeks to capture capabilities or skills that are important for ICTs. As these are proxy indicators, rather than directly measuring ICT-related skills, the skills sub-index is given less weight in the computation of the IDI than the other two sub-indices.

Access sub-index captures ICT readiness that reflects the level of networked infrastructure and

Table 3. The values of the ICT sub-indices and the ranks by these sub-indices for Eastern European and CIS countries in 2002 and 2017

Country	Access 2002	Rank 2002	Access 2017	Rank 2017	Use 2002	Rank 2002	Use 2017	Rank 2017	Skills 2002	Rank 2002	Skills 2017	Rank 2017
Czech Republic	4,73	32	7,14	55	0,8	34	6,62	39	7,65	30	8,27	28
Hungary	4,05	36	7,78	37	0,61	44	5,71	56	8,12	34	7,7	46
Slovakia	3,76	39	7,22	51	1,34	23	6,67	36	7,36	45	6,67	36
Poland	3,34	43	7,58	40	0,72	39	5,47	64	8,57	17	8,35	25
Bulgaria	2,64	54	6,83	65	0,3	61	6,23	45	7,81	37	8,17	35
Romania	2,4	59	6,98	60	0,22	66	5,59	61	7,16	48	7,25	60
Russian Federation	2,36	60	7,23	50	0,14	80	6,13	51	8,53	20	8,62	13
Ukraine	1,94	72	6,6	71	0,06	104	3,17	116	8,41	21	8,56	15
Belarus	1,92	74	7,87	34	0,3	62	6,54	40	8,19	31	8,93	5
Moldova	1,63	85	7,56	42	0,12	83	5,12	70	7,15	49	6,89	68
Georgia	1,56	90	6,26	79	0,05	110	4,47	80	7,39	43	7,49	54
Kazakhstan	1,55	93	7,55	43	0,06	109	5,69	58	7,69	39	7,48	55
Armenia	1,52	95	6,52	72	0,07	100	4,42	83	6,98	57	6,94	66
Kyrgyzstan	1,05	119	4,54	114	0,1	90	2,91	118	7,54	41	6,96	65
Uzbekistan	0,96	132	5,24	95	0,04	117	3,93	93	6,77	69	6,17	87
Azerbaijan	0,91	136	6,62	70	0,12	82	5,55	62	6,49	72	6,67	72

access to ICTs. In this rating Ukraine almost didn't change its position being 72 among 154 countries in 2002 and 71 among 176 countries in 2017. But in 2002 Ukraine was outrun only by Russia (60) and the post-socialist states of Eastern Europe (they ranked from 32 (Czech Republic) to 59 (Romania)). In 2017 Ukraine was excelled also by Belarus (34), Moldova (42), Kazakhstan (43), and Azerbaijan (70). So the dynamics by the access sub index was rather negative for Ukraine, moreover taking into consideration the remarkable progress of other CIS countries.

But the worst situation lies within the position of Ukraine in the Use sub index ranking that characterizes the ICT impact – the results/outcomes of more efficient and effective ICT use. In 2002 Ukraine ranked 104 leaving behind only Kazakhstan (109), Georgia (110), and Uzbekistan (117). In 2017 Ukraine became one of the outsiders by that sub-index (116) along with Kyrgyzstan (118). Ukraine lost 12 positions at the same time when

Belarus gained 22 positions, Moldova – 13, Georgia – 20, Kazakhstan – 51, Armenia – 17, Uzbekistan – 24, Azerbaijan – 20 positions respectively. Therefore, it's necessary to explore how the indicators that constitute the Use sub index have changed.

The Component Indicators of the ICT Use Sub-index

This sub index includes three intensity and usage indicators: individuals using the Internet, fixed-broadband subscriptions and mobile-broadband subscriptions.

In 2002 the percentage of individuals using the Internet in Ukraine (0,72) was very low in comparison with 4 Eastern European countries: Czech Republic (9,78), Slovakia (9,43), Poland (7,29), and Hungary (7) but quite comparable with other countries of the region. The quantity of Internet users in Ukraine in 2000–2016 compared with

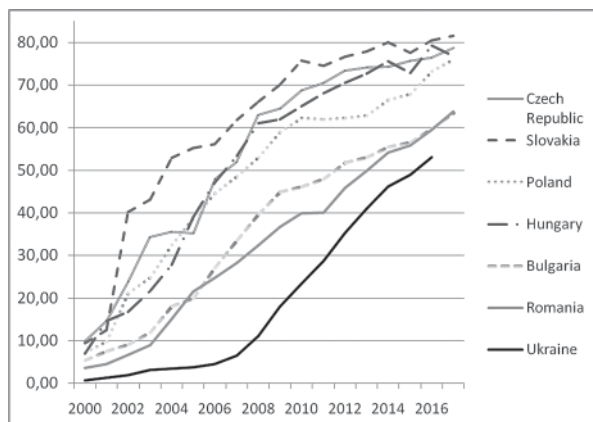


Fig. 1. The percentage of individuals using the Internet in Ukraine and Czech Republic, Slovakia, Poland, Hungary, Bulgaria in 2000–2016

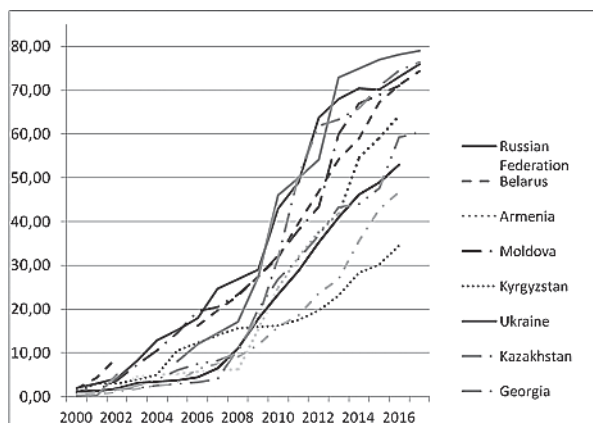


Fig. 2. The percentage of individuals using the Internet in Ukraine and Russian Federation, Belarus, Armenia, Moldova, Kyrgyzstan, Kazakhstan, Georgia in 2000–2016

several other countries of Eastern Europe and the CIS is shown at the Fig. 1 and 2. However, by 2006 Ukraine hasn't succeeded to increase the quantity of internet users substantially, the percentage of internet users equalled only 4,51 that was more than in Kazakhstan only (3,27). All other listed countries were ahead. For example, in Moldova, the Russian Federation, and Belarus 19,62; 18,02, and 16,2 percent of inhabitants respectively used the Internet. The Czech Republic which back then still was ranked as a regional leader had 56,08% of Internet users, more than the half of the whole population. Since 2010 Ukraine has ranked above

Kyrgyzstan and Uzbekistan and behind all other countries. Moreover, Uzbekistan (46,79) has gotten quite closely to Ukraine (53) by 2016. Meanwhile, Kazakhstan (76,43) and Azerbaijan (79) have achieved the same level by that indicator as Slovakia (81,63), Czech Republic (78,72), and Hungary (76,75) in 2017.

The number of fixed broadband subscriptions per 100 inhabitants was extremely low in the whole region from 6,91 in Czech Republic to 0,02 in Belarus in 2005. Ukraine was in the middle of the list with 0,28% of subscriptions.

The number of fixed broadband subscriptions per 100 inhabitants in Ukraine and Czech Republic, Slovakia, Poland, Hungary, Bulgaria, Romania in 2002–2017 shown on Fig. 3. The number of fixed broadband subscriptions per 100 inhabitants in Ukraine and Russian Federation, Belarus, Armenia, Moldova, Kyrgyzstan, Kazakhstan, Georgia, Azerbaijan, Uzbekistan in 2002–2017 shown on Fig. 4.

Since 2008 Ukraine has been losing its position in the middle and was outrun by other countries: in 2008 by Belarus, in 2009 by Moldova, in 2011 by Kazakhstan and Azerbaijan, in 2012 by Georgia, in 2014 by Armenia. But in 2015 Ukraine managed to register more fixed broadband subscriptions per 100 inhabitants than Armenia.

The quantity of active mobile-broadband subscriptions per 100 inhabitants was also very low in all countries in 2007: from 6,3 in Poland to 0,1 in Belarus. There were only 0,6 of mobile-broadband subscriptions in Ukraine then. By 2012 the number of mobile-broadband users had increased quite significantly.

The Russian Federation took the lead with 60,2 subscriptions and Ukraine was an outsider with 6,7 subscriptions in 2012. Moreover, the second lowest rated country Georgia had 17,4 active mobile-broadband subscriptions per 100 inhabitants then. Therefore, Ukraine obviously hadn't developed that technology to any sufficient extent as of 2007–2012. In 2016 Ukraine was still far behind other countries in the region with only 22,6 subscriptions. Meanwhile, there were 88,4 active mobile-broadband subscriptions per 100 inhabitants in Bulgaria, 78,7 – in Slovakia, 76 – in Czech Republic.

Connection between IDI and GNI

There is a strong and significant correlation between the IDI 2017 values and GNI per capita, suggesting that the level of economic development has a significant bearing on ICT development [9]. This is probably, at least to some degree, a self-sustaining phenomenon: it is likely that GNI per capita levels influence both the level of consumer demand to make use of ICTs and the level of infrastructure investment in access networks to meet that demand. Outliers, which show significantly better IDI performance than might be anticipated from GNI per capita, are worth to be considered further, as their experience may indicate that countries have implemented policy or investment choices which are more effective in leveraging ICT access and use. Not surprisingly, outliers that significantly outperform their GNI per capita level include countries at the top of the IDI 2017 distribution, such as Iceland, the Republic of Korea and Denmark. Over-achieving countries at lower levels of economic performance include Estonia, Bulgaria, Belarus, Serbia, Ukraine and Moldova.

The relationship between GNI per capita and IDI for Ukraine is shown at the Fig. 5.

The trend of a strong interrelationship between the IDI values and GNI per capita is quite relevant for Ukraine. In 2007–2008 the growth of GNI per capita was accompanied by the increase in IDI almost in the same pace. After a disastrous drop of income in 2008 the IDI 2009 didn't rise almost at all in comparison with the IDI 2008. After 2009 GNI per capita grew rather quickly approximately at the same pace as in 2007–2008 but IDI increased constantly but not as fast as income. In 2014–2015 GNI per capita fell drastically again almost to the level of 2009. At the same time IDI 2014–2016 froze. Thus, it has only slightly exceeded the level of 2013 by 2016. In 2017 the significant increase in GNI per capita allowed Ukraine to reach the income level of 2014. It was the fastest growth of this indicator during 2007–2017. Also it was the first time after 2013 when IDI rose substantially.

Ukraine was outperforming in the IDI 2002 because it excelled such countries as Romania, Bulgaria, and Kazakhstan in ICT development by the

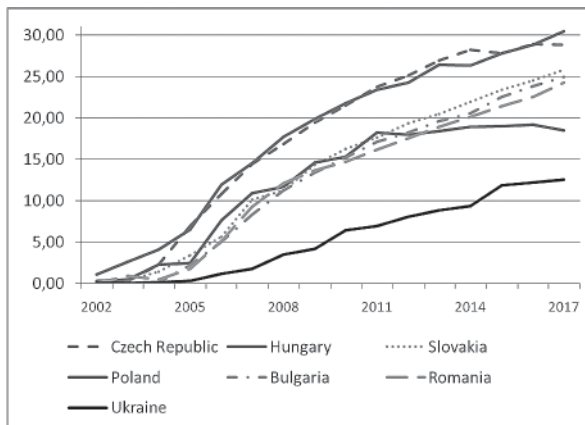


Fig. 3. The number of fixed broadband subscriptions per 100 inhabitants in Ukraine and Czech Republic, Slovakia, Poland, Hungary, Bulgaria, Romania in 2002–2017

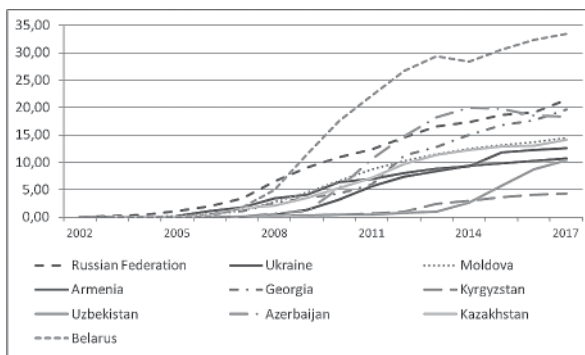


Fig. 4. The number of fixed broadband subscriptions per 100 inhabitants in Ukraine and Russian Federation, Belarus, Armenia, Moldova, Kyrgyzstan, Kazakhstan, Georgia, Azerbaijan, Uzbekistan in 2002–2017

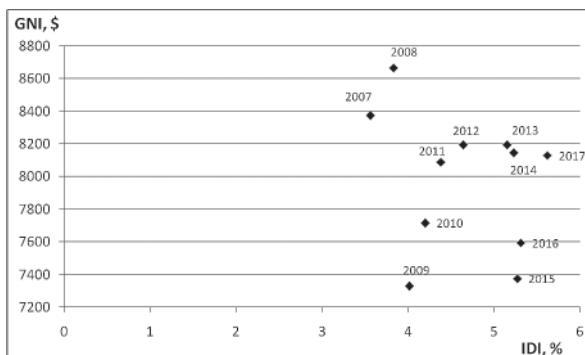


Fig. 5. The relationship between GNI per capita and IDI for Ukraine in 2007–2017

IDI Rank though their GNI per capita was higher then. The GNI of Azerbaijan outran the GNI of

Ukraine in 2006 but in the IDI Azerbaijan managed to leave Ukraine behind only in 2012. Georgia outdistanced Ukraine in both IDI and GNI in 2015. Moldova is the only exception in this trend, because its GNI is still lower than in Ukraine but its IDI exceeded the IDI of Ukraine in 2010 [11].

Digital Divide

Another important issue of measuring the IDI is *digital divide*. The digital divide is usually measured in terms of people's access to ICTs. Penetration levels of mobile cellular telephones, Internet and personal computers are some of the most common measures used.

However, a country may excel in one area, for example mobile cellular penetration, but lag in another, such as Internet penetration. This is where a composite index serves its purpose. The digital divide is known as a relative concept. It compares the level of ICT development in a country, or group of countries, with that in another at a certain point in time. One of the benefits of having a composite measure, such as the IDI, is that it captures the magnitude of the digital divide and how it is evolving over time. According to this concept countries

need to be grouped based on different ICT levels. In the first report Ukraine was referred to as the "Upper" group because its IDI value was between 3,41 and 5,25. Economies included in this category are those that have achieved an elevated level of access to and use of ICTs, and ICT skills, for a majority of their inhabitants. That group included countries from different regions such as Mauritius from Africa, nine countries from Eastern Europe, three countries from South-Eastern Asia, two countries from the Caribbean, four countries from Latin America and seven countries from Western Asia. In total, they accounted for almost 780 million people. The economies included in both that group and in the "High" group accounted for more than 27 percent of the world's population in 2007.

The State of the ICT Market in Ukraine

The state of the ICT markets is characterized by infrastructure developments, and government policy as well as initiatives to improve the access and use of ICTs for households and individuals. It is structured around three key areas: mobile services, fixed services, and government policy.

Table 4. Ukraine: The Key ICT Development Indicators

Key indicators for Ukraine (2016)		CIS	World
Fixed-telephone sub. per 100 inhab.	19,8	20,7	13,6
Mobile-cellular sub. per 100 inhab.	132,6	141,2	101,5
Fixed-broadband sub. per 100 inhab.	12	15,8	12,4
Active mobile-broadband sub. per 100 inhab.	22,6	59,7	52,2
3G coverage (% of population)	90	77,1	85
LTE/WiMAX coverage (% of population)	1,4	45,9	66,5
Mobile-cellular prices (% GNI pc)	1,2	1,7	5,2
Fixed-broadband prices (% GNI pc)	1,1	3,3	13,9
Mobile-broadband prices 500 MB (% GNI pc)	1,2	1,4	3,7
Mobile-broadband prices 1 GB (% GNI pc)	0,9	3,1	6,8
Percentage of households with computer	65,1	67,4	46,6
Percentage of households with Internet access	54,8	68	51,5
Percentage of individuals using the Internet	52,5	65,1	45,9
Int. Internet bandwidth per Internet user (kbit/s)	79,9	59	74,5

Mobile broadband coverage is growing dramatically in Ukraine. More than 20 million people used the 3G network by the end of 2016. Most of broadband access Internet connections are wireless (66 per cent) [12]. The number of fixed telephone users has been decreasing, as well as operator revenues in fixed telephony. Fixed broadband services generate most of the income from Internet access services. Fibre-optic connections are increasingly prevalent among new subscribers. Government policy aims to liberalize legislation. The regulatory authority is planning to simplify market entry of telecommunication companies, and cancel existing practices of licensing specific types of telecommunication services, etc. A legislative framework for effective infrastructure use by market players has been developed. One of the main priorities of government policy is to facilitate the quality of services improvement. Authorities are working on legislation alignment to the European Union framework.

The key indicators for ICT development in Ukraine in comparison with CIS countries and the world level are presented in Table 4.

The data were collected in the spring of 2017 through the short World Telecommunication/ICT Indicators (WTI) questionnaire and the short questionnaire on ICT Access and Use by Households and Individuals. The data on ICT prices were collected in the last quarter of 2016 by means of the ICT Price Basket Questionnaire.

The comprehensive definition of the ICT sector has evolved over time, and its inherent economic activities are grouped into three areas: ICT manufacturing industries, ICT trade industries and ICT services industries [13].

Decrease of telecommunication revenues in Ukraine is a part of a regional trend (Table 5). Revenues fell 14,7 percent in Europe and 36,5 percent in the CIS. The only exception in CIS region is Uzbekistan. This is the result of a combination of factors, including increasing market saturation, weakening macroeconomic growth, intensifying competition and a continued pressure on retail prices. Total telecommunication revenues largely depend on the population of the country. Roughly speaking, the higher the population, the higher expected revenues are supposed to be. That is why

Table 5. Total telecommunication revenues (USD millions), 2014–2016

The World Rank	Economy	2014	2015	2016
15	Russian Federation	39 506	25 089	22 778
24	Poland	12 567	10 517	10 040
51	Czech Republic	3 836	3 039	2 964
52	Hungary	4 037	3 078	2 931
53	Romania	3 380	2 840	2 869
55	Uzbekistan	1 362	1 742	2 191
57	Kazakhstan	3 799	3 167	2 111
59	Ukraine	3 485	2 033	1 910
61	Slovakia	2 240	1 840	1 863
75	Bulgaria	1 502	1 236	1 197
79	Belarus	1 402	1 096	1 084
81	Azerbaijan	2 185	1 602	1 005
103	Kyrgyzstan	519	418	368
107	Georgia	420	311	310
108	Armenia	382	316	288
115	Moldova	325	260	225

the Russian Federation has the highest rank (15) in the group. The fact that Poland ranks 24 position means that the revenues per capita are much higher there. Ukraine ranks 59 among the 154 countries. The mobile ecosystem consists of mobile operators, infrastructure providers, retailers and distributors of mobile products and services, mobile device manufacturers, and mobile content, application and service providers.

The CIS region witnessed the largest mobile revenue decline between 2014 and 2016, of 44 percent. The Russian Federation and Azerbaijan each reported over USD 1 billion in losses in mobile revenues during that period, followed by Kazakhstan, with just over USD 800 million lost mobile revenues. The region can be described as highly saturated, with stalling growth in mobile subscriptions (1,8 per cent between 2014 and 2016) and regional mobile-cellular penetration reaching 141 per cent in 2016, while mobile-broadband subscriptions continue to drive regional growth for the mobile

Table 6. Average revenue per user (ARPU), mobile subscriptions, 2014-2016

The World Rank	USD / subscription / month			
	Economy	2014	2015	2016
44	Hungary	17	12,9	13,4
45	Slovakia	17,8	14,1	12,9
48	Czech Republic	15,1	12,3	12
70	Bulgaria	8,9	7,3	7,1
72	Poland	8,2	7	6,7
76	Romania	7,1	5,8	6,1
86	Uzbekistan	4	4,1	4,9
90	Belarus	6,2	4,7	4,6
97	Armenia	6,9	5	4,3
99	Azerbaijan	12	6,6	4,2
106	Russian Federation	7,1	4	3,5
115	Moldova	3,9	3,1	2,9
117	Georgia	4	2,7	2,7
118	Kyrgyzstan	3,8	3,2	2,6
123	Kazakhstan	4,6	3,7	2,3
127	Ukraine	3,1	1,7	1,8

ecosystem (from 47,3 to 59,7 per 100 inhabitants in the period 2014–2016) [13].

Ukraine had the lowest average revenue per mobile subscriber in the group in 2014 being behind Kyrgyzstan, Moldova, and Uzbekistan (Table 6). In 2015–2016 Ukraine was on the last position again outrun by other countries substantially. This can also be explained by the 30% lower prices for mobile cellular subscriptions along with a high saturation of the market compared with the average level in CIS.

Among transitioning economies such as Ukraine, the prospects for inward Foreign Direct Investment (FDI) (all sectors included) is moderately positive. In Ukraine, the business environment is characterized by slow reforms which limit greenfield investment. These trends are largely reflected in telecommunication-specific FDI which, between 2015 and 2016, declined by 10 percent in Ukraine [13].

Nevertheless, as the authors of the „Measuring Information Society 2017 Report“ state, Ukraine has a great potential regarding the mobile and fixed-broadband market development. Operators are eager to introduce new services and attract new subscribers. They also come to conclusion that work is underway to develop new legislation in the sector of information and telecommunication technologies in Ukraine. New strategies for digital transformation, big data, blockchain and agile are discussed at state level. The mobile ecosystem consists of mobile operators, infrastructure providers, retailers and distributors of mobile products and services, mobile device manufacturers, and mobile content, application and service providers.

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The forecast of the percentage of individuals using the Internet in Ukraine, Belarus, and Kazakhstan

The forecasted percentage of individuals using the Internet by 2025 will be calculated, Then the results of these calculations will be compared for Ukraine, Belarus, and Kazakhstan.

The procedure given in [14–15] will be used for this purpose, This forecast is built by the means of the combinatorial GMDH algorithm with after-determination model by the error bias criterion [16–17].

To do this, prepare a data sample of individuals using the Internet in Ukraine for the period from 2005 to 2016 (Tabl. 6).

The output value is set the number of Internet users in Ukraine for the year ahead ($y = x_{k+1}$), the input variables select the variables: x_k – the current value of the number of Internet users in Ukraine, x_{k-1} – the value of Internet users in Ukraine a year ago (delayed value), x_{k-2} – two years ago, etc.

Such an autoregressive models will be developed for this purpose:

$$y = x_{k+1} = f(x_k, x_{k-1}, x_{k-2}, x_{k-3}, x_{k-4}).$$

According to the combinatorial GMDH algorithm of we get a model for Ukraine:

$$y_U = 2,194 + 1,678 x_{Uk} - 0,703 x_{Uk-1},$$

$$AR = 8,198, BS = 0,0177,$$

where AR – the regularity accuracy criterion; BS – the error bias criterion,

Similarly, we will build a model for Belarus:

$$y_B = 2,213 + 1,520 x_{Bk} - 0,595 x_{Bk-2},$$

$$AR = 2,74, BS = 1,389,$$

For Kazakhstan: $y_K = 7,34 + 0,96 x_{K(k)},$

$$AR = 8,33, BS = 0,018.$$

In order to make calculations for the forecast the Table 7 is built where the percentage of individuals using the Internet for one step forward is an output variable. The results of forecasting for Ukraine, Belarus, and Kazakhstan by 2025 are shown in the Table 8 and on the Fig. 7.

Therefore, the percentage of individuals using the Internet in Ukraine will reach the same level as in Belarus by 2022. At the same year Kazakhstan is supposed to achieve the level of full saturation of its market because the whole population of this country is forecasted to get a possibility to use Internet then. Thus, growth rates of Internet users show the most impressive pace in Kazakhstan; meanwhile the indicators for Ukraine have increased much slower since 2009. The percentage of Internet users in Belarus keeps on the same level in 2025 as nowadays. Therefore, Ukraine will be on the point of overtaking Belarus in the end of the forecasted period but won't count on the same number of individuals using the Internet as in Kazakhstan because of extensive development of ICTs there.

Analysis of the obtained results

Analysis of the IDI 2017 sub-indices of Ukraine showed that Ukraine is the only country in the world where both the difference between the skills and overall IDI rankings and the difference be-

Table 7. Data for forecasting of the percentage of individuals using the Internet

Var.	x_k	x_{k-1}	x_{k-2}	x_{k-3}	x_{k-4}	$y=x_{k+1}$
2005	3,75	3,49	3,15	1,87	1,24	4,51
2006	4,51	3,75	3,49	3,15	1,87	6,55
2007	6,55	4,51	3,75	3,49	3,15	11,00
2008	11,00	6,55	4,51	3,75	3,49	17,90
2009	17,90	11,00	6,55	4,51	3,75	23,30
2010	23,30	17,90	11,00	6,55	4,51	28,71
2011	28,71	23,30	17,90	11,00	6,55	35,27
2012	35,27	28,71	23,30	17,90	11,00	40,95
2013	40,95	35,27	28,71	23,30	17,90	46,24
2014	46,24	40,95	35,27	28,71	23,30	48,88
2015	48,88	46,24	40,95	35,27	28,71	53,00
2016	53,00	48,88	46,24	40,95	35,27	—

Table 8. The results of the forecasting of the percentage of individuals using the Internet in Ukraine, Belarus, and Kazakhstan till 2025.

Country	Belarus	Ukraine	Kazakhstan
2000	1,86	0,72	0,67
2001	4,30	1,24	1,01
2002	8,95	1,87	1,67
2003	10,76	3,15	2,00
2004	12,58	3,49	2,65
2005	14,39	3,75	2,96
2006	16,20	4,51	3,27
2007	19,70	6,55	4,02
2008	23,00	11,00	11,00
2009	27,43	17,90	18,20
2010	31,80	23,30	31,60
2011	39,65	28,71	50,60
2012	46,91	35,27	61,91
2013	54,17	40,95	63,30
2014	59,02	46,24	66,00
2015	67,30	48,88	70,83
2016	71,11	53,00	74,59
2017	74,44	56,74	76,43
2018	75,39	59,94	81,32
2019	75,36	62,77	86,07
2020	73,07	65,27	90,66
2021	69,00	67,47	95,11
2022	70,00	69,40	99,41
2023	63,30	70,67	103,58
2024	70,60	71,75	107,62
2025	75,00	72,67	111,52

tween access and the use rankings are the biggest in the world.

Ukraine belongs to the 14 countries within IDI 2017 that have rankings for access 20 or more places higher than their rankings for usage. And in Ukraine this divergence is the highest in the world and it equals 45 positions. This imbalance in favour of the access sub-index suggests that there is scope for policy interventions to stimulate demand and usage in the country. Demand-side policies to stimulate greater use of available infrastructure are

more likely to raise the level of ICT development. The largest positive differences between the skills sub-index and the overall IDI 2017, which have the effect of improving overall IDI performance, are those for Cuba (which ranks 62nd in the skills sub-index but 137th in the overall Index) and Ukraine (which ranks 15th in the skills sub-index but 79th overall).

Also it should be mentioned that the skills sub-index rather assess the length and involvement of population in the process of education but not its quality. Therefore, this sub-index definitely improves the position of Ukraine in IDI, and in reality the situation in the field of development of necessary skills for use of ICTs may be worse.

Analysis of three intensity and usage indicators of the Use-subindex reveals that though in 2002 the number of individuals using the Internet in Ukraine was very low, whereas on the same level as in other CIS countries.

Ukraine hasn't managed to increase this indicator in contrast to others by 2006. Since 2010 Ukraine has ranked above Kyrgyzstan and Uzbekistan and behind all other countries of the region. Moreover, the percentage of individuals using the Internet in Ukraine was 20% lower than the average of CIS in 2016. As for fixed broadband subscriptions per 100 inhabitants, this service only arose in 2005. The progress of Ukraine in developing this service was very slow and since 2008 Ukraine has been losing its position in the ranking of this indicator towards other countries situated in our region.

The number of fixed-broadband subscriptions per 100 inhabitants in Ukraine was 24% lower than the average in CIS in 2016. The ranking based on the quantity of active mobile-broadband subscriptions per 100 inhabitants was established for the first time in 2007. This market started to grow thereafter. But by 2012, Ukraine had shown the lowest pace of developing this service in the region. The number of active mobile-broadband subscriptions per 100 inhabitants was 62% lower than the average in CIS in 2016.

This means that even though Ukraine made progress in developing these services the pace how it was done was enormously slow in comparison with other CIS countries.

Analysis of the key ICT development indicators of Ukraine shows that Ukraine was behind or far behind (by some indicators) other CIS countries in 2016. Only few indicators such as fixed-telephone subscriptions per 100 inhabitants, mobile-cellular subscriptions per 100 inhabitants, percentage of households with computers are just a bit lower than average in CIS and higher than the world average. But the first two indicators (fixed-telephone and mobile-cellular subscriptions) will be excluded from the next IDI 2018 and replaced by new ones. Therefore, it may even worsen the overall position of Ukraine in the IDI 2018. Ukraine lags behind CIS average by about 20% in the fields of fixed-broadband subscriptions per 100 inhabitants, percentage of households with Internet access, and percentage of individuals using the Internet – also on the same level by the first indicator, but exceeds the world average by the remaining two.

However, Ukraine fell back considering the number of active mobile-broadband subscriptions per 100 inhabitants by 62% (that pulls down its position in the Use-subindex and overall IDI) and by LTE/WiMAX coverage (% of population) in 97% in 2016. Thus, only 1,4% of Ukrainian population was covered by 4G in comparison with 45,9% in the CIS region and 66,5% globally. Hopefully, the indicator will rise in the next report because Ukrainian mobile providers have actively introduced 4G technology recently.

Respectively, if Ukrainians didn't have access to 4G they had to use 3G extensively. Thus the 3G coverage (% of population) indicator was 90 in Ukraine in 2016 when it was 77,1 in CIS and 85 in the world. Only the International Internet bandwidth per Internet user (kbit/s) was 35% higher than the CIS average and 7% higher than the world average in 2016.

As for the ICT services prices, mobile-cellular prices (% GNI pc) were 30% lower than the CIS average, fixed-broadband prices (% GNI pc) 57%, mobile-broadband prices 500 MB (% GNI pc) 14%, and mobile-broadband prices 1 GB (% GNI pc) 71% lower. Such low mobile-cellular and fixed as well as mobile broadband prices can sometimes be a mixed advantage: on the one hand, they bring affordable services to the reach of people living on

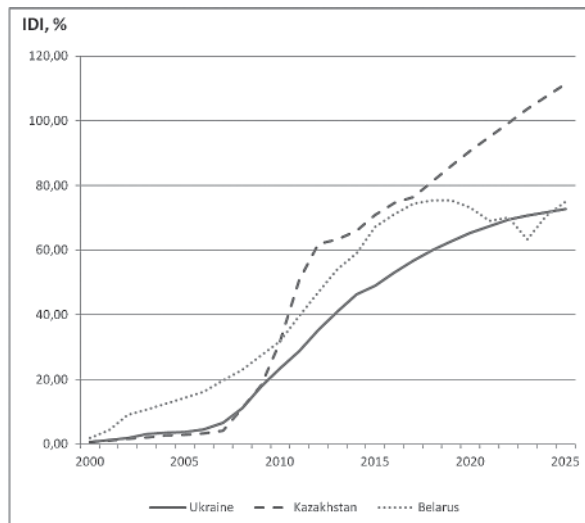


Fig. 7. The results of the forecasting of the percentage of individuals using the Internet in Ukraine, Belarus, and Kazakhstan till 2025

low-income; on the other hand, if prices are too low, they may threaten the long-term sustainability of the market.

It is the task of regulators and policy-makers to strike a balance between these two forces because Ukraine had the lowest average revenue per mobile subscriber in the CIS group in 2014–2016.

Therefore, broadband in Ukraine is fast and cheap (affordable), though take-up is still relatively low – around half the population are connected to the internet. It means there is a substantial digital divide between those who use the internet under very favourable conditions (mostly urban population) and those who have no internet access (predominantly those who live in rural areas and small towns). Ukraine has lagged in development of mobile broadband by 2016 though that technology became the main driver for the mobile ecosystem revenues in the region. This also may be a reason for the lowest average revenue per mobile subscriber in CIS.

Anyway, since 2016 4G technology has been widely developing and the number of active mobile-broadband subscriptions grew constantly, hopefully Ukraine will decrease its digital divide with other countries of the region. Ukraine is featured as a country that has great potential for mobile and fixed-broadband market development. However, the slight pace of progress in IDI that Ukraine

demonstrated in 2014–2016 is definitely not sufficient in order to outperform in ICT development in the nearest future. Efficient efforts of the government are necessary to be made in this field.

Conclusions

The IDI of Ukraine and its subindices were analyzed in comparison with the same indicators of Eastern European and CIS countries in 2002–2017. The reason of slow progress of Ukraine in this ranking is turned out to be insufficient growth of such compo-

nents of use subindex as the percentage of individuals using Internet, the number of fixed broadband subscriptions per 100 inhabitants, and the number of active mobile-broadband subscriptions per 100 inhabitants.

The results of the forecasting of the percentage of individuals using the Internet in Ukraine, Belarus, and Kazakhstan till 2025 showed that Ukraine will be on the point of overtaking Belarus in the end of the forecasted period but won't reach the level of Kazakhstan because of much more extensive development of ICTs there.

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УКРАЇНА У РЕЙТИНГУ РОЗВИТКУ ІНФОРМАЦІЙНО-КОМУНІКАЦІЙНИХ ТЕХНОЛОГІЙ. II

Вступ. Індекс розвитку інформаційно-комунікаційних технологій (ІКТ) – це комплексний, універсальний і загально визнаний показник, що характеризує досягнення країни з точки зору розвитку ІКТ. Він розраховується Міжнародним союзом електров'язку. Цей індекс обраний такими країнами як Казахстан і Росія одним з контрольних для дослідження розвитку ІКТ у цих країнах. Оскільки ці країни досягли значного успіху у розвитку ІКТ за останні роки, то необхідно вивчати їхні підходи до вимірювання змін у цій сфері.

Мета статті. Для оцінювання рівня розвитку і прогресу України у розвитку ІКТ порівняно з іншими країнами Східної Європи і СНГ проведено дослідження того, як Україна змінювала свою позицію у рейтингу, розробленому на основі індексу розвитку ІКТ, у період з 2002 по 2017 роки. Також метою статті є дослідження шляхів для скорочення цифрового розриву, тобто різниці у рівні розвитку ІКТ, яка виникла між Україною та іншими країнами регіону, а також вивчення потенціалу подальшого розвитку ІКТ в Україні і ступеня, у якому Україна може скористатися ними для економічного зростання, виходячи з наявних інфраструктурних, технологічних і людських ресурсів.

Методи. Системний підхід, аналіз.

Результат. Проведено аналіз прогресу України у рейтингу, складеному на основі індексу розвитку ІКТ, у порівнянні з іншими країнами регіону, проведено дослідження динаміки підіндексів індексу розвитку ІКТ та їх компонентів у 2002–2017 роках, основних характеристик рівня розвитку ІКТ в Україні на 2016 рік, телекомунікаційного ринку України у 2014–2016 роках, а також проведено дослідження зв'язку між ВВП і індексом розвитку ІКТ. Побудовано моделі, які дозволяють аналізувати розвиток інформаційних і телекомунікаційних технологій в Україні.

Висновок. Результати цього дослідження показують, що, починаючи з самого початку досліджуваного періоду, прогрес України у розвитку ІКТ був дуже повільним у порівнянні з іншими країнами регіону. Україна відстала від середнього рівня по регіону СНД майже за усіма показниками. Однак, в останні роки з'явилися позитивні тенденції, зокрема була запроваджена технологія 4G, збільшується кількість користувачів ширококутного доступу, який є основним чинником зростання телекомунікаційного ринку. Однак, для швидкого скорочення цифрового розриву, що виник між Україною та її сусідами, потрібно ще докладати чимало зусиль.

Ключові слова: *індекс розвитку інформаційних і комунікаційних технологій, цифровий розрив, показники глобального розвитку, цифровий порядок денний України.*

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УКРАИНА В РЕЙТИНГЕ РАЗВИТИЯ ИНФОРМАЦИОННО-КОММУНИКАЦИОННЫХ ТЕХНОЛОГИЙ. II

Введение. Индекс развития информационно-коммуникационных технологий (ИКТ) – это комплексный, универсальный и общепризнанный показатель, характеризующий достижения страны с точки зрения развития ИКТ. Он рассчитывается Международным союзом электросвязи. Этот индекс избран такими странами как Казахстан и Россия в качестве одного из контрольных для исследования развития ИКТ в этих странах. Поскольку эти страны достигли значительного успеха в развитии ИКТ за последние годы, то необходимо изучать их подходы к измерению прогресса в этой сфере.

Цель статьи. Для оценки уровня развития и прогресса Украины в развитии ИКТ в сравнении с другими странами Восточной Европы и СНГ проведено исследование того, как Украина меняла свою позицию в рейтинге, разработанном на основе индекса развития ИКТ, в период с 2002 по 2017 годы. Также целью статьи является исследование путей для сокращения цифрового разрыва, т. е. разницы в уровне развития ИКТ, которая возникла между Украиной и другими странами региона, а также изучение потенциала дальнейшего развития ИКТ в Украине и степени, в которой Украина может воспользоваться ими для экономического роста, исходя из имеющихся инфраструктурных, технологических и человеческих ресурсов.

Методы. Системный подход, анализ.

Результат. Проведен анализ прогресса Украины в рейтинге, составленном на основе индекса развития ИКТ, в сравнении с другими странами региона, проведено исследование динамики подиндексов индекса развития ИКТ и их компонентов в 2002–2017 годах, основных характеристик уровня развития ИКТ в Украине на 2016 год, телекоммуникационного рынка Украины в 2014–2016 годах, а также проведено исследование связи между ВНД и индексом развития ИКТ. Построены модели, позволяющие анализировать развитие информационных и телекоммуникационных технологий в Украине.

Вывод. Результаты этого исследования показывают, что, начиная с начала исследуемого периода, прогресс Украины в развитии ИКТ был очень медленным в сравнении с другими странами региона. Украина отстала от среднего уровня по региону СНГ почти по всем показателям. Однако, в последние годы появились положительные тенденции, в частности была введена технология 4G, увеличивается количество пользователей широкополосного доступа, который является основным фактором роста телекоммуникационного рынка. Однако, для быстрого сокращения цифрового разрыва, возникшего между Украиной и ее соседями, нужно еще приложить немало усилий.

Ключевые слова: индекс развития информационных и коммуникационных технологий, цифровой разрыв, показатели глобального развития, цифровая повестка дня для Украины.