

## ECONOMETRIC ASSESSMENT OF THE IDENTIFICATION OF STRUCTURAL PROCESSES IN THE ICT SECTOR OF THE UKRAINIAN ECONOMY

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**Abstract.** The development of the ICT sector of Ukraine's economy has been influenced by globalization, European integration, and the policy of digitalization of the economy. Since the early 2000s, the ICT sector has undergone significant structural shifts, in particular, due to growing external demand for ICT services and imports of ICT goods. The paper has aimed to conduct an econometric assessment to identify structural processes in the ICT sector in Ukraine. The methodology of the study is based on a mixed-method design combining qualitative and quantitative assessments of the structural processes of the Ukrainian ICT sector over the period 2000–2021, in particular, statistical analysis and regression analysis of ICT sector dynamics. The results of an econometric estimation of structural processes in the ICT sector in Ukraine show the following shifts: 1) growth of the ICT sector's share in the economy in 2000–2021 to 4.6%; 2) the dominance of telecommunications, and computer programming and information services in the ICT sector by the number of companies and the volume of their sales; 3) the key external factor for the growth of the ICT sector in Ukraine is the growing external demand for the services of the sector, while the internal factors restraining the growth of the industry are insufficient demand and financial constraints for enterprise development; 4) econometric analysis shows that a 1% increase in Internet usage increases the share of ICT in GDP by 0.018% and a 1% increase in the share of imports of ICT goods increases the share of ICT in GDP by 0.364%. The practical value of the research findings lies in the empirical assessment of the structural processes' key factors in the ICT sector in Ukraine. In particular, this includes the demand for services, imports of foreign equipment for the production of services, and the level of Internet usage in Ukraine.

**Keywords:** ICT sector structural processes, ICT and economic growth, ICT sector development factors, ICT sector structural shifts

### 1 Introduction

The accelerated use and expansion of the Internet as a means of communication, mobile Internet, social networks, and commercial platforms, usually perceived as digitalization, have significantly shaped the functioning and state of the economy, businesses, and public institutions in Ukraine. The integration of information and communication technologies (ICT) has contributed to the development and structural shifts in Ukraine's ICT sector. Ukraine has identified digital transformation as a policy priority, marked by recent successes in the implementation of ProZorro and eHealth, the 4G mobile network, and the introduction of e-services in the public and private sectors. Digitalization in Ukraine is a joint effort of the expert and business communities, and in 2018 the government adopted the Ukrainian Digital Economy and Society Development Concept and Action Plan for 2018–2020. Priorities for the Ukrainian digital agenda include legislation on the digital economy and telecommunications, digital infrastructure, including a broadband strategy. This includes a cashless economy program on e-commerce, e-trust, and cybersecurity, as well as the "Smart Cities – Smart Regions" initiative, focused on decentralization and implementation of e-skills, e-health, and e-commerce in all regions of Ukraine. The above-mentioned features of ICT integration require a detailed study of the structural processes in the ICT sector and the main factors affecting changes in its dynamics and structure.

The paper aims to conduct an econometric assessment to identify structural processes in the ICT sector in Ukraine.

### 2 Literature review

The scientific literature studies the dynamics and development of the ICT sector and its interaction with economic growth, economic openness, investment, and trade. Quantitative analysis, including the use of econometric methods to study the ICT sector, has been carried out in the works of Holm & Østergaard (2015), Murshed (2020), Erumban & Das (2016), Latif et al. (2018), Barefoot et al. (2018), Jorgenson & Vu (2016), Lee & Brahmaresne (2014), Vu (2013), Bilan et al. (2019), Xing, Ye & Kui (2011), Park, Meng & Baloch (2018), Nordhaus (2015), Bahriani & Qaffas (2019), Sassi & Goaid (2013), Whalen,

Milios & Nussholz (2018), Salahuddin & Alam (2016), Salahuddin, Alam & Ozturk (2016), Partanen & Möller (2012), Holm & Østergaard (2015). They study Denmark's ICT sector in the context of regional growth and employment. Murshed (2020) examines the non-linear trade openness effects of the ICT sector based on empirical analysis. Erumban & Das (2016) examine the relationship between the ICT sector and India's economic growth, looking at the impact of ICT sector investment on the economy and ICT productivity growth. Latif et al. (2018) assess the dynamics of the ICT sector, foreign investment, globalization, and economic growth for BRICS economies over 2000–2014, showing the long-run elasticity between ICT and economic growth, and the causal relationship between globalization and ICT. Barefoot et al. (2018) identify the growth of the US digital economy. Jorgenson & Vu (2016) explore the ICT sector revolution and the impact of ICT investment on global economic growth. Lee & Brahmaresne (2014) estimate the impact of ICT on South Asian economic growth based on 1991–2009 data, showing a significant positive relationship between the variables. Vu (2013) argues for the significant impact of ICT on Singapore's economic growth over the period 1990–2008. In particular, it refers to the impact of ICT intensity on value-added and productivity. At the same time, ICT investment accounts for 1% of the country's GDP growth. Bilan et al. (2019) prove the impact of ICT on foreign economic growth through correlation analysis. Xing, Ye & Kui (2011) investigate the evolution of convergence of China's four ICT manufacturing sectors over 1997–2002. They found a higher level of supply-side convergence of the manufacturing sectors compared to the convergence of the services sectors in 2002. In addition, they found a high complementary convergence between some of China's ICT manufacturing and services sectors; the prevalence of ICT supply convergence over ICT services convergence, and little structural change in the demand convergence of China's diverse ICT sub-sectors.

Park, Meng & Baloch (2018), based on panel data from EU countries from 2001–2014, failed to show a positive impact on the use of ICT sector technologies on sustainable development. Nordhaus (2015) explores the problem of singularity through technology and artificial intelligence. Bahriani & Qaffas (2019) estimate the impact of information and communication technology (ICT) on economic growth over the period 2007–2016 using data from the Middle East and Africa. Econometric modeling results show that ICTs are major drivers of economic growth in developing countries. Sassi & Goaid (2013) use the example of MENA countries to show the significant positive impact on economic growth, particularly the financial sector at a certain level of ICT integration. Pradhan, Arvin & Norman (2015) examine the dynamics of ICT infrastructure, economic growth, and financial development in a case study of Asian countries over the period 2001–2012, identifying the short- and long-term relationship of the variables.

Thus, the empirical results and linkages of the ICT sector and economic growth have been sufficiently covered in the literature, particularly in the context of economic growth through ICT investment, productivity, competitiveness, sustainability, financial sector development, etc. At the same time, few studies have identified structural processes in the ICT sector of the Ukrainian economy. Most of the research on the ICT sector in Ukraine deals with ICT dynamics in the context of EU ICT sector studies, Eastern Europe, quantitative assessment of ICT sector dynamics, etc. Therefore, it is advisable to assess the structural processes, shifts, and quantitative changes in the ICT sector in Ukraine.

### 3 Methodology

The study is based on a mixed design combining qualitative and quantitative assessments of the structural processes of the ICT sector in Ukraine over the period 2000–2021. To quantify the

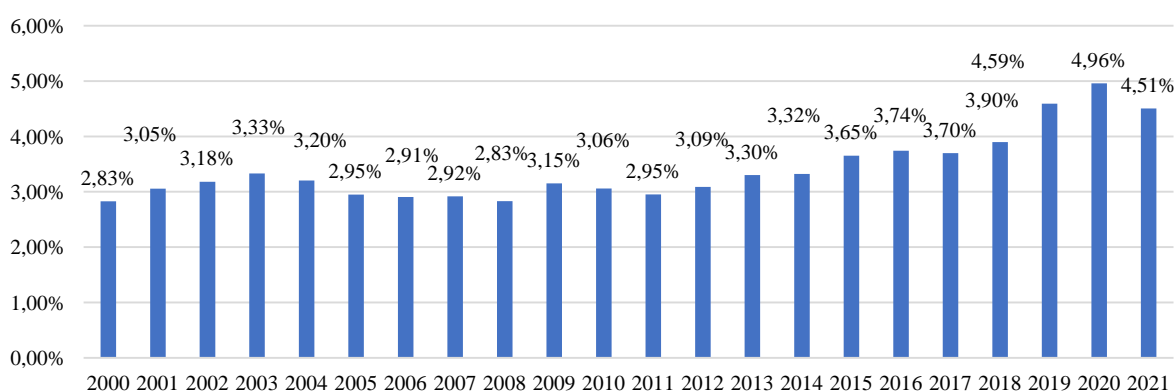
structural processes of the ICT sector, the method of statistical analysis of the following indicators has been used: 1) dynamics of the share of ICT in GDP in Ukraine; 2) the number of operating ICT sector enterprises in Ukraine by sub-sector; 3) dynamics of product sales by enterprises in general and by the ICT sector in Ukraine by sub-sectors; 4) dynamics of ICT service exports in Ukraine; 5) dynamics of the influence factors on the ICT sector according to the survey of enterprises (demand, labor force, infrastructure and equipment, financing); 6) macroeconomic factors of influence on ICT sector: GDP growth (annual %), ICT goods exports, individuals using the Internet, ICT goods imports. The key indicators to assess the structural processes of the ICT sector were the evolution of the number of enterprises and their sales volume in the following sub-sectors: software publishing, telecommunications, computer programming, consulting and related activities, provision of information services (including data processing, web hosting, and related activities; web portals.

Econometric evaluation of structural processes in the ICT sector was carried out using linear regression, the statistical significance of which was tested using Fisher's F-Test and coefficient of determination. The statistical significance of regression equation coefficients was assessed using t-statistics and p-value with an error rate of 5%. The econometric assessment involved the construction of regression equations between the share of the ICT sector in Ukraine's GDP and GDP growth rate, the share of exports, imports of ICT goods in total exports, and the share of Internet users in Ukraine.

#### 4 Results

Ukraine has shown rapid growth in innovation in the ICT sector, which has become an important segment of the country's economy and has made striking progress in the deployment of high-speed broadband. The ICT sector's share of the country's GDP has reached 4,6% and the number of mobile phone service contracts is over 125% (Figure 1).

Figure 1: Dynamics of ICT as a share of GDP in Ukraine, 2000–2021



Source: calculated by the author according to the State Statistics Service of Ukraine (2022a).

In comparison, the average share of the ICT sector in EU-27 GDP was 4,1% in 2008–2018 (Eurostat, 2022b), having grown

by 0,34% in ten years. Table 1 presents a ranking of EU countries in terms of ICT development between 2008 and 2018.

Tab. 1: Classification of EU countries in terms of ICT development based on 2008–2018 data

Average value	Group I countries – high level of development	Group II countries – intermediate level of development	Group III countries – low level of development
The average share of the ICT sector in the EU-27 GDP, %	Malta 7,97%, Bulgaria 6,1%, Hungary 5,95%, Sweden 5,94%, Estonia 5,38%	Latvia 4,92%, Finland 4,85%, Czech Republic 4,56%, Denmark 4,56%, Croatia 4,45%, Germany 4,4%, France 4,31%, Slovakia 4,13%, Iceland 4,03%, Belgium 3,96%, Romania 3,74%, Poland 3,59%, Slovenia 3,59%, Austria 3,58%	Norway 3,37%, Italy 3,29%, Spain 3,28%, Lithuania 3,13%, Greece 2,49%
The average share of people employed in ICT as a percentage of total employment, %	Malta 4,77%, Sweden 4,75%, Estonia 4,3%, Latvia 4,15%	Finland 3,79%, Hungary 3,6%, Denmark 3,51%, The UK 3,43%, Slovakia 3,31%, Germany 3,16%, Switzerland 3,16%, Czech Republic 3,13%, Norway 3,08%, France 3,07%	Belgium 2,85%, Bulgaria 2,85%, Slovenia 2,72%, Lithuania 2,64%, Austria 2,63%, Croatia 2,57%, Poland 2,54%, Romania 2,52%, Spain 2,48%, Italy 2,43%, Greece 1,51%

Source: formed by the author according to Eurostat (2022a; 2022 b).

All countries can be classified by the level of ICT sector development into three groups: 1) high level of development with a share of ICT in GDP of more than 5%, which includes Malta 7,97%, Bulgaria 6,1%, Hungary 5,95%, Sweden 5,94%; Estonia 5,38%; 2) Intermediate level of development with ICT share in GDP being in the range of 3,5% to 5%, including Latvia 4,92%, Finland 4,85%, Czech Republic 4,56%, Denmark 4,56%, Croatia 4,45%, Germany 4,4%, France 4,31%, Slovakia 4,13%, Iceland 4,03%, Belgium 3,96%, Romania 3,74%, Poland 3,59%, Slovenia 3,59%, Austria 3,58 3) Low development level, with less than 3,5% share of ICT in GDP, which includes Norway 3,37%, Italy 3,29%, Spain 3,28%, Lithuania 3,13%, Greece 2,49%. Accordingly, the share of people employed in the ICT sector and the labour market demand for ICT professionals differs across EU countries (Eurostat, 2022a). The average share of those employed in ICT was 2,79% in the EU-27 between

2009 and 2018. The countries with the highest share of ICT employment are Malta 4,77%, Sweden 4,75%, Estonia 4,3%, Latvia 4,15%, which can be classified as the group with the most developed digital economy, where the share of employment exceeds 4%. The group of countries with an intermediate ICT employment rate in the range of 3–4% includes the following: Finland 3,79%, Hungary 3,6%, Denmark 3,51%, UK 3,43%, Slovakia 3,31%, Germany 3,16%, Switzerland 3,16%, Czech Republic 3,13%, Norway 3,08%, France 3,07%. The group of countries with low rates of ICT employment includes (less than 3%): Belgium 2,85%, Bulgaria 2,85%, Slovenia 2,72%, Lithuania 2,64%, Austria 2,63%, Croatia 2,57%, Poland 2,54%, Romania 2,52%, Spain 2,48%, Italy 2,43%, Greece 1,51%. The number of operating ICT sector enterprises in Ukraine averaged 4,04% of the total number of all enterprises in 2014–2020. At the same time, the dynamics of the number of enterprises in the

ICT sector exceeded the rate of the number of enterprises in general (Table 2), amounting to 20,53% and 9,62% respectively. The highest growth rates were in the following ICT sub-sectors: computer programming (76,35%), computer hardware management activities (68,06%), provision of information

services (41,96%) and web portals (132,14%). At the same time, computer programming (22%), IT consulting (9%), information services (17%) and telecommunications (electro communication) (13%) sub-sectors accounted for the largest share of sales volumes according to the 2014–2020 average.

Tab. 2: Number of operating enterprises in general and the ICT sector in Ukraine, 2014–2020

Types of economic activity	2014	2018	2019	2020	Absolute deviation, +/-	Growth rate, %
Total	341001	355877	380597	373822	32821	9,62%
information and telecommunications	13319	14515	15917	16054	2735	20,53%
software release	358	381	411	397	39	10,89%
computer games release	58	57	63	63	5	8,62%
release of other software	300	324	348	334	34	11,33%
telecommunications (electrocommunication)	1694	2017	2006	2008	314	18,54%
activities in the field of wireline telecommunications	1189	1454	1442	1454	265	22,29%
wireless telecommunications activities	252	264	255	230	-22	-8,73%
satellite telecommunications activities	24	18	21	22	-2	-8,33%
other activities in the field of telecommunications	229	281	288	302	73	31,88%
computer programming, consulting, and related activities	4194	5278	6152	6499	2305	54,96%
computer programming	2491	3374	4031	4393	1902	76,35%
consulting on information issues	1234	1311	1440	1443	209	16,94%
computer hardware management activities	72	94	115	121	49	68,06%
other information technology and computer systems activities	397	499	566	542	145	36,52%
provision of information services	2047	2553	2854	2906	859	41,96%
data processing, web hosting, and related activities; web portals	1081	1344	1500	1537	456	42,18%
data processing, web hosting, and related activities	997	1182	1319	1342	345	34,60%
web portals	84	162	181	195	111	132,14%
provision of other information services	966	1209	1354	1369	403	41,72%

Source: State Statistics Service of Ukraine (2022b).

The volume of sales by the ICT sector was slightly higher than the volume of sales by the enterprises as a whole (Table 3). At the same time, the share of the ICT sector's sales volumes averaged 1,95% over 2014–2020. The following sub-sectors of the ICT sector in Ukraine had the highest growth rate: computer games publishing (940,46%), computer programming (407,71%), informatization consulting (278,24%), and computer hardware management activities. (728,95%), provision of information services (323,03%), data processing, posting of information on websites and related activities (339,9%), and web portals (567,9%). The largest share of the Ukrainian ICT sector is represented by the following sectors: telecommunications (telecommunications) with 41% including 12% wireline telecommunication activities and 29% wireless telecommunication activities; computer programming, consulting, and related activities with 33% including 25% computer programming and 5% IT consulting; information services with 10% including 8% data processing, website hosting, and related activities.

Among the growth drivers of Ukraine's ICT sector is the growing external demand for the sector's services (Figure 2). While in 2000 the share of the ICT service exports in Ukraine was 1,2% of the total, in 2010 it was 3,9%, in 2020 – 33,3%, and 2021 – 38,1%. At the same time, the dynamics of EU ICT service exports are less vibrant.

According to a survey of the managers of the ICT sector conducted by the State Statistics Service of Ukraine, the performance of the ICT sector in Ukraine is constrained by insufficient demand and development constraints (Table 4). The factors positively influencing the activities of the ICT sector

enterprises are the availability of a qualified labor force and equipment.

Managers of surveyed ICT enterprises in January–March 2022 claimed no change in demand for ICT services (61% of respondents), 19% reported a future increase in demand and 20% reported a decrease (Figure 3).

Factors influencing the ICT sector include the growth of the economy and industries actively integrating ICT to optimize their operations and ensure competitiveness and growth in productivity (Table 5). It should be noted that Ukraine experienced an average GDP growth rate in 2016–2019, with a decline of 3,75% in 2020 due to the pandemic, forcing domestic enterprises to search for external markets for services and to enter new markets. Meanwhile, exports of ICT goods from Ukraine amounted to only 0,73% of exports, while imports of ICT goods stood at 5,95% in 2020. Thus, the ICT industry in Ukraine is service-oriented through the purchase of foreign equipment to produce ICT services. A significant factor influencing the development of ICT is the demand of the population, as evidenced by the growth of Internet users in Ukraine from 23,3% in 2010 to 75,04% in 2020.

The correlation analysis shows a high direct correlation between the share of ICT in GDP and people's use of the Internet (0,839), and a high direct relationship between the ICT share in GDP and imports of ICT goods (0,871). At the same time, an inverse low correlation was found between the share of ICT in GDP and GDP growth (-0,257) and exports of ICT goods (-0,205). This means that exports of ICT goods are a drag on the growth of the ICT sector in Ukraine.

Tab. 3: Dynamics of product sales by enterprises in general and the ICT sector in Ukraine, 2014-2020, bln UAH.

Types of economic activity	2014	2018	2019	2020	Absolute deviation, +/-	Growth rate, %
Total bln. UAH	4170,66	9206,05	9639,73	10049,87	5879,21	140,97%
information and telecommunications	84,10	165,28	198,28	218,14	134,04	159,38%
software release	0,62	1,23	1,56	1,95	1,34	216,48%
computer games release	0,04	0,27	0,33	0,41	0,37	940,46%
release of other software	0,58	0,96	1,23	1,54	0,97	167,20%
telecommunications (electrocommunication)	44,83	59,71	67,98	75,64	30,80	68,71%
activities in the field of wireline telecommunications	13,31	16,64	18,61	19,72	6,41	48,16%
wireless telecommunications activities	30,75	41,40	47,40	53,56	22,81	74,19%
satellite telecommunications activities	0,07	0,08	0,11	0,08	0,00	1,55%
other activities in the field of telecommunications	0,70	1,59	1,87	2,28	1,58	225,77%
computer programming, consulting, and related activities	18,55	59,81	73,85	87,34	68,80	370,92%
computer programming	13,48	47,33	57,61	67,64	54,16	401,71%
consulting on information issues	3,32	9,31	10,64	12,57	9,25	278,24%
computer hardware management activities	0,08	0,51	0,72	0,63	0,56	728,95%
other information technology and computer systems activities	1,66	2,66	4,88	6,49	4,83	290,11%
provision of information services	5,89	18,51	22,41	24,90	19,01	323,03%
data processing, web hosting, and related activities; web portals	4,92	15,50	18,76	21,63	16,71	339,90%
data processing, web hosting, and related activities	4,85	15,30	18,50	21,21	16,35	336,96%
web portals	0,06	0,20	0,26	0,42	0,36	567,90%
provision of other information services	0,97	3,01	3,65	3,27	2,30	237,51%

Source: State Statistics Service of Ukraine (2022c).

Figure 2: ICT service exports (% of service exports)



Source: World Bank (2022a).

Tab. 4: Estimated impact of ICT constraints (average shares for 2015–2022), %

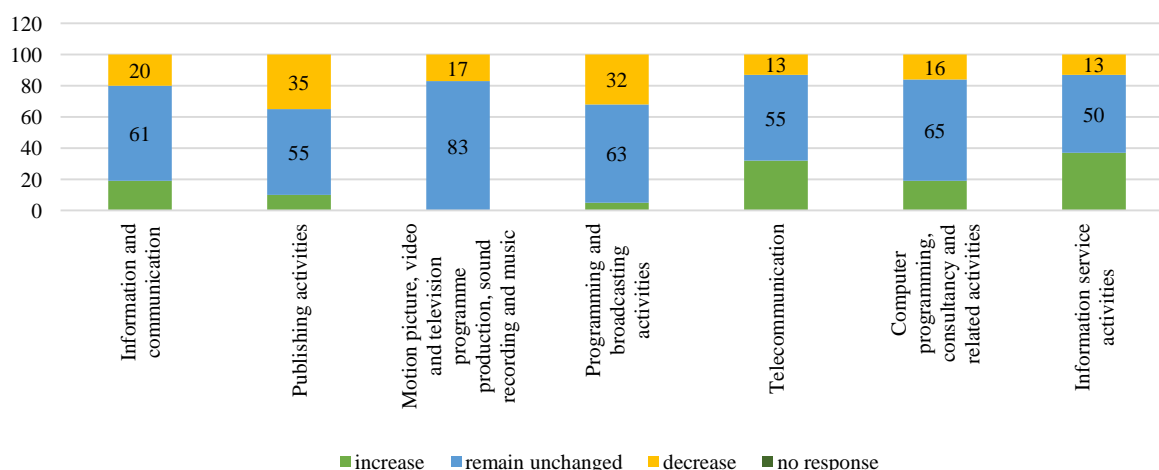
	insufficient demand	shortage of labor force	shortage of space, equipment	financial constraints	other factors	nothing is hindering
Information and telecommunications	31,34	6,17	2,83	31,86	39,38	19
Publishing activities	38,41	3,00	2,76	41,17	35,14	17
Production of the motion picture, videos, television programs, and sound recordings	33,21	0,93	3,83	38,10	34,62	19
Radio and television broadcasting activities	39,83	2,14	0,69	38,48	43,34	12
Telecommunications (electric communication)	20,97	5,86	2,17	41,97	55,28	10
Computer programming, consulting, and related activities	28,93	11,62	4,07	18,31	34,10	25
Information service activities	26,21	8,14	2,17	22,17	35,72	25

Source: State Statistics Service of Ukraine (2022d).

Regression analysis suggests that Internet use and imports of ICT goods affect the share of the ICT sector in Ukraine's GDP. With a significance level of 5%, a 1% increase in Internet usage accounts for a 0,018% increase in the share of ICT in GDP. At the same time, the 70,3% regression equation explains the change in the share of ICT in GDP by the change in the share of Internet users. The significance of the t-statistic is tested by calculating a p-value not exceeding 5%.

With a significance level of 5%, a 1% increase in the share of imports of ICT goods would result in a 0,364% increase in the share of ICT in GDP. A 75,9% regression equation explains the change in the share of ICT in GDP by the change in the share of imports of ICT goods.

Figure 3: Expected changes in demand on ICT services (of turnover) at SCT service enterprises over the next 3 months (January–March 2022), %



Source: State Statistics Service of Ukraine (2022d).

Tab. 5: Main impact factor on ICT industry development in Ukraine, 2000–2020

Indicator Name	2000	2010	2016	2017	2018	2019	2020
GDP growth (annual %)	5,90	4,09	2,44	2,36	3,49	3,20	-3,75
ICT goods exports (% of total goods exports)	1,52	1,07	0,95	0,93	0,98	0,83	0,73
Individuals using the Internet (% of the population)	0,72	23,30	53,00	58,89	62,55	70,12	75,04
ICT goods imports (% total goods imports)	2,50	3,19	4,88	5,13	5,80	6,59	5,95

Source: World Bank (2022b).

Tab. 6: Correlation factor: ICT share and main impact factor

	ICT share in GDP, %	GDP growth (annual %)	ICT goods exports (% of total goods exports)	Individuals using the Internet (% of the population)	ICT goods imports (% total goods imports)
ICT share in GDP, %	1,000				
GDP growth (annual %)	-0,257	1,000			
ICT goods exports (% of total goods exports)	-0,205	0,090	1,000		
Individuals using the Internet (% of the population)	0,839	-0,452	-0,134	1,000	
ICT goods imports (% total goods imports)	0,871	-0,151	-0,233	0,863	1,000

Source: author calculation based on data World bank (2022b).

Tab. 7: Regression analysis

Factor	GDP growth (annual %)	ICT goods exports (% of total goods exports)	Individuals using the Internet (% of the population)	ICT goods imports (% total goods imports)
Regression	$ICT\_share = 3,408 - 0,021 GDP\_growth$	$ICT\_share = 3,787 - 0,449 ICT\_goog\_exp$	$ICT\_share = 2,837 + 0,018 Indiv\_us\_In$	$ICT\_share = 2,004 + 0,364 ICY\_good\_imp$
R	0,066	0,042	0,703	0,759
F	1,338	0,831	45,175	59,907
f-test	0,261	0,373	2,008	0,000
t-statistic	26,566, -1,156	7,869, -0,911	27,238, 6,721	11,265, 7,740
p-value	0,000, 0,262	0,000, 0,373	0,000, 0,000	0,000, 0,000

Source: author calculation.

#### 4.1 Dynamics of the IT sector of the Ukrainian economy

As of today, the state of ICT development in Ukraine is far ahead of the state of development of legislation in this area. The state of development of the information society and the ICT sector in Ukraine, compared to global trends, is insufficient and does not meet the strategic development goals of Ukraine.

Legislation in the field of telecommunications does not meet the needs of operators, telecommunications providers, or the interests of consumers of telecommunications services. Improving and reforming legislation in the sphere of information and communication technologies is the main task of legislative development in Ukraine.

IT clusters are engaged in the development of the IT industry in the city, bringing together leading companies and partners working in software product development and export outsourcing. Ukraine has about 185,000 developers and 4,000 IT companies, and the technology sector was the country's second-largest export sector in 2018. Moreover, 20% of global leaders, including Microsoft, Samsung, ABBY, and Huawei, have offices in Ukraine. According to the Fortune 500 list, more than 100 companies use the services of Ukrainian firms, with 18 outsourcers from Ukraine in the top 100 outsourcing companies in the world (Sokolenko, 2020).

There are 22 IT clusters in Ukraine in such cities as Kyiv, Kharkiv, Lviv, Dnipro, Odesa, Ternopil, Konotop, Sumy,

Chernihiv, Cherkasy, Vinnytsia, Lutsk, Mariupol, Zaporizhzhia, Ivano-Frankivsk, Kolomyia, Mykolaiv, Kherson, Khmelnytskyi, Chernivtsi, Severodonetsk, Zhovti Vody. The five most active IT clusters in Ukraine have 192,000 specialists or 89.7% of the total number of people employed in the IT sector in Ukraine (Table 8).

The dynamics of the IT market are measured primarily by the number of the main asset – personnel. In recent years, this market has shown stable growth of 10–12% year on year. This is one of the few areas of the labor market that, despite the crisis phenomena, not only is not shrinking but is also showing consistent growth.

Tab. 8: Number of companies and IT professionals: Top 5 IT clusters in Ukraine.

Name of IT Cluster	Number of staff employed by IT companies	Number of IT companies
Kyiv IT Cluster	90,000	58
Kharkiv IT Cluster	45,000	511
Lviv IT Cluster	31,000	511
Dnipro IT Cluster	16,000	378
Odesa IT Cluster	10,000	6
Zaporizhzhia IT Cluster	7,000	–
Vinnytsia IT Cluster	5,000	–
Mykolaiv IT Cluster	4,000	2
Ternopil IT Cluster	3,000	–
Kherson IT Cluster	3,000	16
Total:	214,000	1482

Source: compiled by the author based on IT Ukraine Association, Office of effective adjustment (2018).

In 2015, N-iX estimated the number of IT professionals in Ukraine at 91,000 and profits at \$2.7bn. 2018 estimates that the number has already reached around 154,000, of which 39,000 (25%) work for the largest 25 IT companies: Epam, SoftServe, GlobalLogic, Luxoft, Ciklum, Infopulse, NIX, ELEKS, EVOPLAY, DataArt, etc. As of 2019, there were 184,500 IT professionals, over 4,000 technology companies, and \$4.5 billion in exports (Pyshchulina, 2020). By the end of 2019, the number of IT professionals in Ukraine was around 200,000. In 2020, the figure rose to 214,000 professionals. GlobalLogic Ukraine estimates that, under favorable conditions, the IT sector could grow to \$8.4bn or 2.3 times by 2025 (Pyshchulina, 2020). This rapid growth can easily be explained by the perspective, prestige, and dynamism of the IT sector in Ukraine. There are also some advantages in terms of the working environment, from access to advanced technology to flexible working hours in most offices.

The main forms (models) of IT business organization are the following (Pyshchulina, 2020):

1. Freelancing. As part of self-employment, the development of information technology in Ukraine has led to the spread of remote employment (remote work, teleworking, freelancing). Most Ukrainian freelancers work either in the IT sphere or in related areas. The Ukrainian freelance market share by categories was as follows: IT (Web, Mobile & Software Development) – 83%, design and creative – 6%, other categories (translation, SMM, sales and marketing, engineering, architecture, etc.) – 11%.

According to some experts, it is the private sector in Ukraine that shows the greatest interest in digitalization, which supports the claim that the digitalization of economic activity and the widespread application of information technology contributes to productivity growth and the efficiency of entrepreneurial activity. The field of information technology in Ukraine is practically based on sole proprietor workers. Data on the number of registered sole proprietors became available in April 2016. The share of individual entrepreneurs in the IT sector among other individual entrepreneurs increased from 5% to 7.5%. According to Opendatobot, the number of individual entrepreneurs in the IT sector has increased by 45% (by 40,7 thousand) since 2016 (while the total number of individual entrepreneurs has decreased by 8%). Thus, the positive dynamics

are characteristic of the IT sector solely. In other types of activities, the dynamics are negative. According to Mind24 (regarding the IT Ukraine Association), according to open data from the register of individual entrepreneurs at the beginning of 2018, there were 127,000 registered programmers. About 90% of them are registered as sole proprietors (Pyshchulina, 2020).

2. Outsourcing. According to experts, the Ukrainian IT market is mainly outsourced. That is, it provides services to foreign companies and is not in too much of a hurry to set up its own technology companies. Outsourcing companies may exist and actively develop even without the institutional capacity of the state and proper infrastructure. The market for outsourcing services in Ukraine is developing at a superfast pace. According to various expert estimates, the market growth is in the range of 10–25% annually. Business process outsourcing is more common, involving the transfer of standardized routine operations (e.g. handling customers' phone calls in specialized call centers, usually located in places with a cheaper workforce). According to studies in Ukraine, outsourcing is more common: IT services (40.5%), logistics (35.1%), resource support for production processes (27%), marketing services (21.6%), recruitment (18.9%), accounting (13.5%), payroll (13.5%), information processing and systematization (8.1%), outsourcing of medical representatives (8.1%), HR records and personnel support (5.4%), administrative functions (2.7%) (Pyshchulina, 2020).

## 5 Discussion

An econometric analysis of the structural processes of Ukraine's ICT sector indicates that there is no correlation between the share of ICT in GDP and the growth rate of Ukraine's economy. Similar conclusions are drawn in Erumban & Das (2016), in which the authors found a mediating effect of ICT on overall factor productivity growth in the ICT-using and ICT-producing sectors. Erumban & Das (2016) found that investment in India's ICT sector drives aggregate economic growth in the services sector. This study finds that the share of ICT in GDP depends on imports of ICT products from other countries. Thus, ICT imports drive Ukraine's services sector, which is mainly export-oriented. India also has similar characteristics of an export-oriented ICT sector, which is boosting its fast-growing services economy. As in Ukraine, India's ICT is limited to the manufacturing sector.

both countries have great potential for the use of ICT in the manufacturing sector. The Government of Ukraine has developed a digitalization of industry projects. It will help harness the potential of the ICT sector to ensure the growth of the domestic manufacturing sector and, as a consequence, the growth of the economy, productivity, and investment in ICT. In Ukraine today, though, ICT is focused on the provision of services to external markets: analysis shows a predominance of the telecom, computer programming, information services, and ICT services export growth sectors. In addition, evidence of the significant potential of domestic ICT services for the Ukrainian economy is that business leaders have identified insufficient demand and funding as key constraints to development. It should be considered that empirical studies indicate a long-term elasticity between ICT and economic growth, suggesting that ICT positively contributes to economic growth (Lee & Brahmašre, 2014; Latif et al., 2018). Therefore, Ukraine's industrial digitalization project may become a future strategic document for realizing the potential of Ukraine's ICT sector in the context of meeting the needs of the economy. As Jorgenson & Vu (2016) point out, "policy approaches are crucial to stimulate an ICT revolution to promote economic growth". Jorgenson & Vu (2016) show, using China and India as examples, how regulatory policies for the ICT sector contribute to economic growth.

## 6 Conclusion

An econometric assessment of structural processes in the ICT sector in Ukraine reveals the following shifts in the industry: 1) growth of the ICT sector's share in the economy to 4,6% in 2000–2021; 2) the dominance of telecommunications, and computer programming, along with the information services in the ICT sector by the number of companies and the volume of their sales; 3) the key external factor for the growth of Ukraine's ICT sector is the growth of external demand for the sector's services, while the internal constraints on the sector's growth are insufficient domestic demand and financial constraints on enterprise development. Econometric estimation shows that a 1% increase in Internet usage increases the share of ICT in GDP by 0,018%. A 1% growth in the share of imports of ICT goods would result in a 0,364% growth of the ICT share in GDP. Thus, an empirical assessment of the key factors of structural processes in the Ukrainian ICT sector proves that the demand for ICT services, imports of foreign equipment for the production of ICT services, and the level of Internet usage in Ukraine are the driving factors of structural processes in the industry. At the same time, no correlation has been found between economic growth and the growth of the ICT sector's share of Ukraine's GDP and the growth of the ICT sector's export share. This is due to the ICT sector's focus on service exports and the sector's long-term impact on economic growth.

Further research should focus on the dynamics of related industries in the ICT sector and their relationship to ICT development in Ukraine, in particular, assessing the short- and long-term effects of the impact.

## Literature:

- Bahrini, R., & Qaffas, A. A. (2019). Impact of information and communication technology on economic growth: Evidence from developing countries. *Economics*, 7(1), 21.
- Barefoot, K., Curtis, D., Jolliff, W., Nicholson, J. R., & Omohundro, R. (2018). Defining and measuring the digital economy. US Department of Commerce Bureau of Economic Analysis, Washington, DC, 15.
- Bilan, Y., Mishchuk, H., Samoliuk, N., & Grishnova, O. (2019). ICT and economic growth: Links and possibilities of engaging. *Intellectual Economics*, 13(1), 93–104.
- Erumban, A. A., & Das, D. K. (2016). Information and communication technology and economic growth in India. *Telecommunications Policy*, 40(5), 412–431.
- Eurostat (2022a). Percentage of the ICT personnel in total employment. Eurostat. 2021. Available at [https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc\\_bde15ag&lang=en](https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_bde15ag&lang=en)
- Eurostat (2022b). Percentage of the ICT sector in GDP. Eurostat. 2021. Available at [https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc\\_bde15ag&lang=en](https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=isoc_bde15ag&lang=en)
- Holm, J. R., & Østergaard, C. R. (2015). Regional employment growth, shocks, and regional industrial resilience: a quantitative analysis of the Danish ICT sector. *Regional Studies*, 49(1), 95–112.
- IT Ukraine Association, Office of Effective Adjustment (2018). Development of the Ukrainian IT industry. Analytical report 2018. Available at [https://ko.com.ua/files/u125/Ukrainian\\_IT\\_Industry\\_Report\\_UKR.pdf](https://ko.com.ua/files/u125/Ukrainian_IT_Industry_Report_UKR.pdf)
- Jorgenson, D. W., & Vu, K. M. (2016). The ICT revolution, world economic growth, and policy issues. *Telecommunications Policy*, 40(5), 383–397.
- Latif, Z., Latif, S., Ximei, L., Pathan, Z. H., Salam, S., & Jianqiu, Z. (2018). The dynamics of ICT, foreign direct investment, globalization, and economic growth: Panel estimation robust to heterogeneity and cross-sectional dependence. *Telematics and Informatics*, 35(2), 318–328.
- Lee, J. W., & Brahmašre, T. (2014). ICT, CO2 emissions and economic growth: evidence from a panel of ASEAN. *Global Economic Review*, 43(2), 93–109.
- Murshed, M. (2020). An empirical analysis of the non-linear impacts of ICT-trade openness on renewable energy transition, energy efficiency, clean cooking fuel access, and environmental sustainability in South Asia. *Environmental Science and Pollution Research*, 27(29), 36254–36281.
- Nordhaus, W. D. (2015). Are we approaching an economic singularity? information technology and the future of economic growth (No. w21547). National Bureau of Economic Research.
- Park, Y., Meng, F., & Baloch, M. A. (2018). The effect of ICT, financial development, growth, and trade openness on CO2 emissions: an empirical analysis. *Environmental Science and Pollution Research*, 25(30), 30708–30719.
- Partanen, J., & Möller, K. (2012). How to build a strategic network: A practitioner-oriented process model for the ICT sector. *Industrial Marketing Management*, 41(3), 481–494.
- Pradhan, R. P., Arvin, M. B., & Norman, N. R. (2015). The dynamics of information and communications technologies infrastructure, economic growth, and financial development: Evidence from Asian countries. *Technology in Society*, 42, 135–149.
- Pyshchulina O. (2020). The digital economy: trends, risks, and social determinants. Razumkov Centre Report. Kyiv: Zapovit publishing. October 2020. Available at: [https://razumkov.org.ua/uploads/article/2020\\_digitalization.pdf](https://razumkov.org.ua/uploads/article/2020_digitalization.pdf)
- Salahuddin, M., & Alam, K. (2016). Information and Communication Technology, electricity consumption and economic growth in OECD countries: A panel data analysis. *International Journal of Electrical Power & Energy Systems*, 76, 185–193.
- Salahuddin, M., Alam, K., & Ozturk, I. (2016). The effects of Internet usage and economic growth on CO2 emissions in OECD countries: A panel investigation. *Renewable and Sustainable Energy Reviews*, 62, 1226–1235.
- Sassi, S., & Goaid, M. (2013). Financial development, ICT diffusion, and economic growth: Lessons from MENA region. *Telecommunications Policy*, 37(4–5), 252–261.
- Sokolenko, D. (2020). The Top-5 IT Clusters of Ukraine. Available at <https://ucluster.org/blog/2020/04/top5-it-klasteriv-ukraini/>
- State Statistics Service of Ukraine (2022a). Gross domestic product by production method and gross value added by economic activities (2010–2020). Available at [https://www.ukrstat.gov.ua/operativ/operativ2008/vvp/vvp\\_ric/arh\\_vtr\\_u.htm](https://www.ukrstat.gov.ua/operativ/operativ2008/vvp/vvp_ric/arh_vtr_u.htm)
- State Statistics Service of Ukraine (2022b). The number of operating enterprises by economic activity per region (2014–2020). Available at [https://www.ukrstat.gov.ua/operativ/operativ2021/fin/pdp\\_roz\\_reg/kdp\\_ved\\_14-20.xlsx](https://www.ukrstat.gov.ua/operativ/operativ2021/fin/pdp_roz_reg/kdp_ved_14-20.xlsx)
- State Statistics Service of Ukraine (2022c). The volume of products (goods, services) sold by type of economic activity per region (2014–2020). Available at [https://www.ukrstat.gov.ua/operativ/operativ2021/fin/pdp\\_roz\\_reg/orp\\_ved\\_14-20.xlsx](https://www.ukrstat.gov.ua/operativ/operativ2021/fin/pdp_roz_reg/orp_ved_14-20.xlsx)
- State statistics service of Ukraine (2022d). Expectations of service businesses on the prospects for their business activity by type of economic activity (2015–2022). Available at

[https://www.ukrstat.gov.ua/operativ/operativ2022/fin/opd\\_ek/po sl/posl\\_15\\_22\\_ue.xlsx](https://www.ukrstat.gov.ua/operativ/operativ2022/fin/opd_ek/po sl/posl_15_22_ue.xlsx)

26. Ukraine: the country that codes. IT Industry in Ukraine. 2019 Market Report. Available at: [https://s3-eu-west-1.amazonaws.com/new.n-ix.com/uploads/2019/09/26/Software\\_development\\_in\\_Ukraine\\_2019\\_2020\\_IT\\_industry\\_market\\_report.pdf](https://s3-eu-west-1.amazonaws.com/new.n-ix.com/uploads/2019/09/26/Software_development_in_Ukraine_2019_2020_IT_industry_market_report.pdf)

27. Vu, K. M. (2013). Information and communication technology (ICT) and Singapore's economic growth. *Information Economics and Policy*, 25(4), 284–300.

28. Whalen, K. A., Milios, L., & Nuscholz, J. (2018). Bridging the gap: Barriers and potential for scaling reuse practices in the Swedish ICT sector. *Resources, Conservation and Recycling*, 135, 123–131.

29. World Bank (2022a). ICT service exports (% of service exports, BoP). Available at <https://data.worldbank.org/indicator/BX.GSR.CCIS.ZS>

30. World bank (2022b). Ukraine. Available at <https://data.worldbank.org/country/ukraine>

31. Xing, W., Ye, X., & Kui, L. (2011). Measuring convergence of China's ICT industry: An input-output analysis. *Telecommunications Policy*, 35(4), 301–313.

**Primary Paper Section: A**

**Secondary Paper Section: AH**