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ICT AND ECONOMIC GROWTH: LINKS AND POSSIBILITIES OF ENGAGING

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Abstract. *The paper deals with analysis and evaluation of impact of information and communication technologies (ICT) on economic growth at the different hierarchical levels. Based on global tendencies of ICT development and their use as a factor of competitive advantages, it is proved that sustainable socioeconomic growth has acquired features of permanent digital development. For developing countries steep ICT development can enforce new impulse of economic progress, which in turn, is proved by correlation analysis and modeling of ICT factors influence on the main financial results. Considering current ICT development trends in business (based on case study of Ukraine ICT use statistics as one of the developing countries) and their relations with financial results, the main policy making actions aiming at further economic development can be defined. They should be aimed mainly at Internet access outspread and web-technologies effective use, particularly in the field of e-commerce.*
Keywords*: ICT, economic growth, GDP, competitiveness, entrepreneurship.*
JEL Classifications: *L86, M15, O47*

Introduction

Nowadays, the impact of ICT factors on the development of economic and economically driven processes is indisputable. Being one of the rapid economic progress drivers, ICT, especially their IT segment, have both advantages and disadvantages, which only proves their importance and the need to take them into account in economic relations on different levels. Hence, in 2007, for the first time cyber risks appeared not only in the top 10, but also in the top 5 global risks of humanity for the upcoming year. Next time, cyber risks in the form of possible cyberattacks were in the top five in 2012. It is quite telling that since the beginning of 2015, cyber risks have become increasingly relevant to humankind: with varying weight, they surely rank different positions on the list of the top ten most significant global risks (see Table 1).

Table 1: Presence of Cyber Risks in the Ranking of Global Risks Facing Society Determined by the World Economic Forum

Position in Top 10	Years				
	2019	2018	2017	2016	2015
In terms of likelihood	**4** (data fraud or theft); **5** (cyberattacks)	**3** (cyberattacks); **4** (data fraud or theft)	**5** (data fraud or theft); **6** (cyberattacks)	**9** (data fraud or theft)	**9** (data fraud or theft); **10** (cyberattacks)
In terms of impact	**7** (cyberattacks); **8** (critical information infrastructure breakdown)	**6** (cyberattacks)	(-)*	(-)*	**7** (critical information infrastructure breakdown)

(-)* – not in top 10

Source: *authors' compilations, based on (WEF, 2015 – 2019)*

As we see, in earlier periods, cyber risks did not have such a negative impact. Damage to infrastructure, particularly critical damage, could have been caused not necessarily by a planned hacker attack, but by isolated effects or objective information system crashes. However, today, the world faces the risks of massive cyberattacks and, since 2015, massive incident of data fraud or theft using information networks is one of the most likely risks facing our world. In most cases, the motives of such actions are predominantly economic ones and lead to principally noticeable economic losses for countries with weak economic development, including underdeveloped ICTs and feeble information culture of data behaviour. In particular, Kardakov (2017) gives a case study of Ukraine being the aforementioned country that demonstrates such expert estimates with regard to the financial consequences of the attack of a virus known as Petya in June 2017, which lasted only half an hour, but its financial implications were estimated at 0.4% of the annual GDP.

In a similar vein, cyberspace is not only an integral part of economic relations, but, in case of proper ICT use, it also assures benefits by increasing competitiveness of particular activities and entire countries, forming the preconditions for a much faster economic return on the use of all economic resources, not only informational ones. The growing attention of multiple international organisations to the study of ICT factors, to digitalisation in various manifestations, in particular their impact on socioeconomic processes, may serve as evidence of this statement. In the context of ICT analysis, the most famous studies include the research of UN and its subdivisions, in particular ITU and UNCTAD, as well as the WEF using the 'ICT use' as an enabler of productivity on some Global Competitiveness Index pillars and within the Network Readiness Index (NRI) to analyse the development of global information technologies.

The statistical database of both national statistical institutions and international analytical organisations, created today to analyse the dynamics of ICT potential, provides a comprehensive empirical study of the impact of ICT on economic growth. In the scientific literature, such studies are one way or another derived from Porter's theory of competitive advantage (Porter, 1985). Basing on official statistics or own research data, as of today scholars and practitioners have created sufficient methodological tools for such analysis. In particular, Jin & Cho (2015) analysed the impact of ICT on economic development and proved positive economic effect of using such ICT components as IT infrastructure, IT competence, IT investment, and IT trade size. At the same time, in countries with a lower level of development, ICT factors have not yet become a decisive factor in economic growth, and therefore, equitable educational systems and advanced infrastructure structures have been identified as priorities that should be corporately implemented (Wannapan & Chaiboonsri, 2017; Mendy, & Widodo, 2018; Lazányi et al., 2017). To some extent, other studies have also confirmed the discussion of the impact of ICT factors on the economic performance of certain activities. Thus, after analysing service industry performance and basing on the case study of Africa and Eastern Europe, Yeo & Grant (2018) have shown a higher role of traditional financial factors such as access to credit resources. Though such studies reflect current trends for certain groups of countries and types of activity with a certain type of consumer behaviour.

Despite the fact that empirical studies of different levels did not always confirm the dominant role of ICT in economic growth, their importance as one of the key determinants of economic development has been proven both in scientific research and in the practice of digital transformation of the advanced economies of the world. Therefore, the ICT development acceleration as a factor of competitive advantage (at different levels, from personal one to sectoral and national ones) is also an important modern research vector, for instance, with regard to competences and skills of student youth and their personal success (Hu et al., 2018), the impact of ICT employment and incomes (Grishnova et al., 2019; Lechman, 2019), rural residents for rural area development (Tambotoh et al., 2015), the use of smart technologies for the development of successful cities (Liu et al., 2017 Szarowská, 2017; Żelazny, 2017), a new role of communications that enhance social interaction in society (Holovatyi, 2015), changes in the role of ICT factors in the creation of innovative digital technologies and engineering systems, which is especially noticeable today in some industrial sectors, especially in construction (Redwood et al., 2017). Leaders of innovation development quickly adapt their production facilities to new conditions and try using new possibilities of ICT communication. For a given reason they create and transform their own knowledge management system, giving an increasingly important role to its innovative components on the basis of ICT (Mishchuk et al., 2016), and also using these factors to increase total factor productivity (Botrić et al., 2017), the increasing diffusion of ICT in economically-related processes (Lechman, 2018) attributable to network connections.

Using the current methodological tools for ICT research, the ***aim of*** our study is to assess the links between ICTs and economic growth in order to find opportunities for their more successful usage. In this regard, ***research objectives*** include the following: (1) assessing the links between ICTs and the key macroeconomic development indicators (GDP per capita) based on international statistics; (2) the selection of the most significant ICT factors that determine the opportunities for better use of enterprises' productive capacity and the modelling of relevant relationships basing on the case study of one of the transition economies (Ukraine), which ICT potential development can provide a significant impetus for national economic development and strengthening of national financial security.

We performed our research on two levels of economic relations using statistical, economical and mathematical ***methods***, namely:

(1) at the international level: using statistics from international analytical agencies on the ICT development indexes and GDP per capita, for which we used exploratory graph analysis and the correlation analysis of the dependence of the investigated factors (variables);

(2) at the microeconomic level: using a case study with a sample of Ukrainian enterprises subject to a statistical survey regarding ICT use; the study used the simulation of connections with testing hypotheses on the impact of ICT on the dependent variable in the form of sales volumes using the "Data Analysis" function in Excel.

As a result of the approbation of the applied methods, we came up with the conclusions regarding the statistical significance and suitability of the results obtained seeking a way to predict and select the most effective levers of influence on the ICT use for economic development, which we formulated in our conclusions of the study.

Data and Results

Assessment of the Impact of ICT on Economic Growth

In order to study the relations between ICT and economic development, the main indicator of which is GDP per capita, we have formed and tested the following **hypotheses**:

H1 – the high level of ICT development leads to the creation of added value and, accordingly, GDP per capita growth;

H2 – high level of ICT use in businesses leads to the formation of competitive advantages and, accordingly, the growth of their financial and economic results, first of all, income from sales of products, and on this basis, and other financial indicators of the entrepreneurial activity efficiency.

Aiming to test the *first hypothesis* (***H1***) on the example of world statistics, we selected the variables from the following international reports:

✓ ICT Development Index (2017) – Information and Communication Technology Development Index (IDI);

✓ Global Competitiveness Index (2017-2018) – ICT usage components within the technological readiness pillar (9.04-9.07) of the Global Competitiveness Index ("ICT use in GCI");

✓ Index of Economic Freedom (2017) – GDP per capita, USD.

We performed the first stage of the verification basing on the correlation and regression analysis in conjunction with the exploratory graph analysis: for this purpose, we constructed suitable trends that illustrated the relationships (see Fig. 1 and Fig. 2).

In the countries where the IDI and "ICT use in GCI" are approaching a maximum of 10 and 8 correspondingly, we have recorded the highest levels of GDP per capita. Conversely, the countries with the lowest values of ICT usage in economic sectors demonstrate the lowest GDP per capita. The coefficient of determination make it possible to conclude that there is a sufficiently close link between the research parameters of IDI / "ICT use in GCI" and GDP per capita, as well as the reliability of the analysis results.

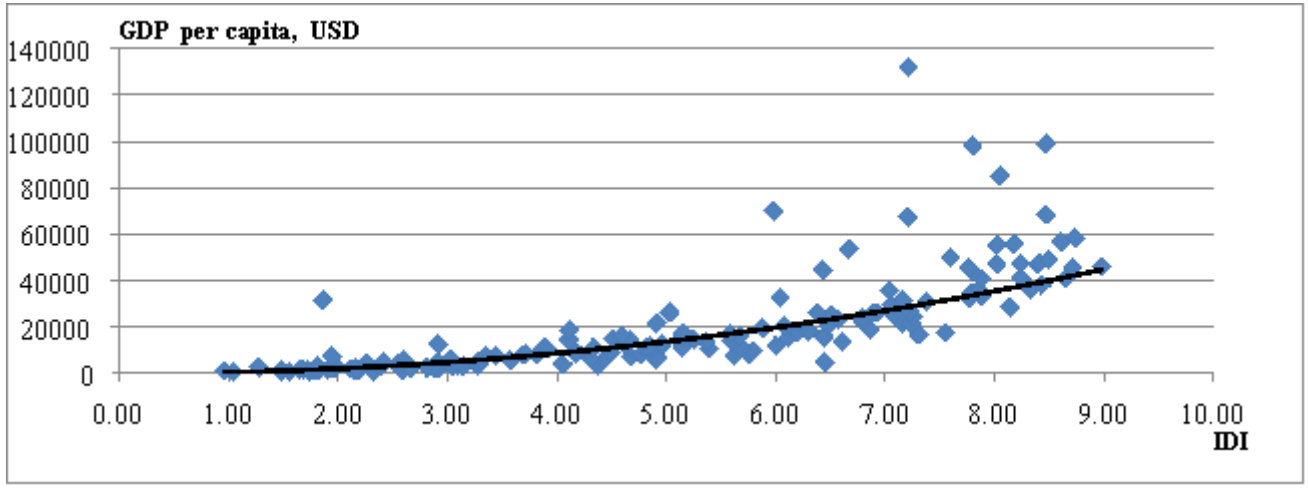

Figure 1: Indicators of Correlation Dependence between GDP Per Capita and IDI level in 2017 (Data for 163 ITU Countries, 2017)

Source: *authors' calculations, based on (ITU, 2017; IEF, 2017)*

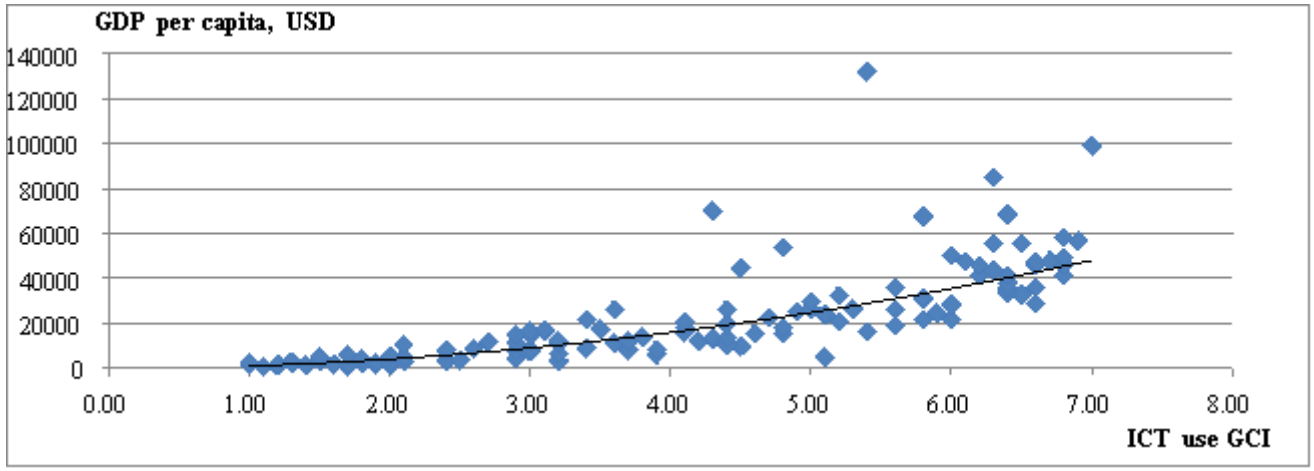

Figure 2: Dependence between GDP per capita and the ICT Component of the Global Competitiveness Index in 2017 (Data for 127 Countries in the 2017-2018 WEF Rating)

Source: *authors' calculations, based on (IEF, 2017; WEF, 2017-2018)*

Testing the *second hypothesis* (***H2***) foresees a micro-level analysis. Thus, we conducted a corresponding research on the case study of Ukraine. In particular, we investigated the materials used in the statistical surveys "Use of Information and Communication Technology at Companies" carried out by the State Statistics

Service of Ukraine (SSSU). Fig. 3 shows the composition of the variables and the results of testing their correlation with the sales volumes.

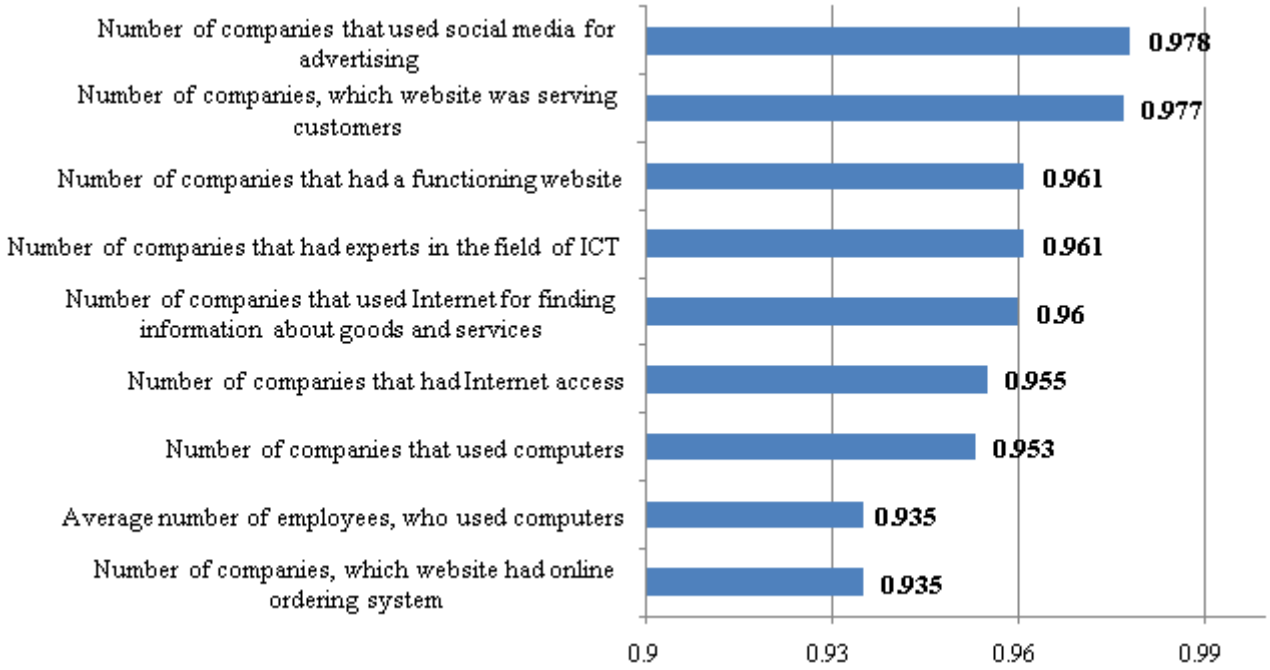

Figure 3: Correlation Coefficients between Sales Volumes (Goods, Services) of Business Entities by Type of Economic Activity and Particular ICT Indicators in 2017

Source: *authors' calculations, based on (SSSU, 2017)*

Fig. 3clearly demonstrates that all indicators the ICT use have a significant direct impact on the sales volume of the companies, as evidenced by the value of the pair correlation coefficients, which are higher than 0.9. Consequently, the higher computerisation level companies get, the greater availability of IT specialists they ensure, the wider Internet use they have, incl. social media and web resources, the higher revenue they receive from sales.

The next step in selecting the variables that are the most appropriate for strengthening economic development with ICT use is the prediction of their impact on GDP based on the simulation of the initially estimated connections. Various stochastic models, for instance those described by Chornei et al. (2005), may be suitable for assessing the laws of economic development based on ICT. However, in view of the available statistical data and a small number of observations that was objectively caused, as well as the correlations confirmed in the process of factor analysis, there is a quite suitable method of forecasting with the use of

regression models. It uses pair regression for international comparisons, in this case one indicator of ICT development is used as factor; as well as multivariate regression – in order to characterise the national model of the ICT impact on the formation of economic results in companies.

Predicting the Impact of ICT on Economic Development (Case Study of Ukraine)

The prediction of the ICT impact on economic development at the macroeconomic level is illustrated by the case study of Ukraine. For this forecast (prediction), we will use two approaches:

- ✓ *Approach 1* is based on the identified connections between GDP and the Information and Communication Technology Development Index (IDI), as well as the ICT use component in the Global Competitiveness Index (see Fig. 1, 2);
- ✓ *Approach 2* is based on the identified connections between the indicators of ICT development at companies of different types of economic activity and built-up relationship correlations of particular factors of ICT development with the indicator of sale volumes shown in Fig. 3.

Therefore, Table 2 demonstrates expected effects of the *first approach*.

At the same time, using international macroeconomic statistics for forecasting may lead to significant errors as the generalised international statistics reflects not only very different levels of economic development, but also very different peculiarities of building up national competitiveness management systems, strategic goals of countries, in particular goals ICT development and different approaches to using them as an economic development factor.

Table 2: Expected Outcomes of the Impact of ICT development factor on Financial and Economic Indicators *(calculated by the author)*

Independent Variable	Regression Equation	Coefficient of Determination / Correlation	Variable Value		GDP Per Capita Growth, USD
			Actual Value	Predicted Value[1]	
IDI	$y= 539.05x^{2.0138}$	0.8144 / 0.9024	5.62	6.89	8,844.531
ICT use in GCI	$y= 1,044.9x^{1.9679}$	0.8151 / 0.9028	3.70	5.0	11,090.8

Source: *authors' calculations*

Therefore, we believe that *approach 2* is more suitable for forecasting, as it is based on taking into account connections between ICT factors and economic outcomes existing in Ukraine.

Thus, in this approach, we have tested different models of multifactorial regression, which included the factors shown in Fig. 3 with values analysed on the basis of the corresponding statistical report (SSSU, 2017). The sales volumes of the companies of the corresponding types of economic activity were viewed as an outcome in the model. The sample covered ten types of economic activity, which were subject to statistical monitoring in 2017. After the approbation of the

connections between various factors with the most statistically significant one, and therefore the most suitable one for prediction and selection of the levers of influence on the formation of economic results, the model was formed as follows:

$$y = -413{,}629 + 154.18x_1 + 1{,}533.17x_2 \quad (1)$$

where y is sales volumes, million UAH; x_1 is the number of companies that have access to the Internet; x_2 is the use of a website to order products and services online (number of companies).

The statistical significance of the model can be confirmed by the results of its verification (see Table 3).

Table 3: Results of Statistical Significance Testing of the Economic and Mathematical Model (1)

No.	Indexes	Estimate
1	Multiple correlation coefficient	0.9746
2	Determination coefficient	0.9501
3	F-statistics (critical value for this model is F = ***0.0517***)	66.6825
4	t-statistics (critical value for this model t = ***1.8949***)	
4.1	x_1	3.2565
4.2	x_2	2.3300

Source: *authors' calculations*

As we have noted before, today the goals of ICT development are one of the most important areas of efforts for both business owners, who have already highly appreciated the benefits of digitisation of their activities, and the government that has an appropriate intent. Taking that into account, in our own calculations, we will make a forecast based on the conditional value of factors' change – their growth is at least 10% per year, although their growth rates may be even higher if they support and intensify the ICT use in business. Hence, by substituting the predicted values of x_1 and x_2 in the model (1), we obtain the predicted value of the growth of sales volumes at the level of 10.41% due to the combined effect of these two factors.

We can predict the macroeconomic effects of such an impact, if we assume that these results will characterise the entire economy, not only a sample of companies, while GDP was 40.1 % in total sales in Ukraine according to 2017 data. Therefore, at the national level the expected GDP growth by improving the use of only two of these factors by 10% will add up to 4.17% (10.41% · 0.401). To put that in context: according to the statistics of national accounts, the share of GDP formed in such branch of economy as "Education" (4.4% of GDP in 2017) was close to this share. The feasibility of our forecast can be confirmed by the data released during the presentation of the Action Plan for the Digitisation of Ukrainian Economy at the Digital Talks, which states that the minimum GDP growth due to digital transformation is expected to be within 2% in 2019, 3% in 2020 and 6% in 2021 (Kubiv, 2018).

Conclusions

Acquiring the most obvious features of digital development, modern economic progress can also contain certain threats, which, at the same time, are way below the new information opportunities that arise due to the rapid diffusion of ICTs in all spheres of economic relations. Hence, both scientists and practitioners increasingly view ICTs as a source of competitive advantage and believe they can serve as the development drivers, which can balance the chances of successful competition of economies with different levels of economic development and create new financial sources of social, not just economic development. An example of international statistics confirms the existence of positive connections between GDP per capita and ICTs, assessed by the most prominent indicators, particularly: IDI (Information and Communication Technology Development Index) and the ICT Component of the Global Competitiveness Index (WEF). The case study of Ukraine as one of the countries that highly appreciates the benefits of digitalisation, but still has less developed economy in terms of information technologies, we have demonstrated the significant impact of ICT on the economic performance of companies. Based on the results of the simulation of these connections, we can state that the next steps to support the ICT development both at the micro-level and at the national level should be focused on increasing the number of individuals, households and businesses with Internet access and efficient use of web technologies, particularly in the field of e-commerce.

The connections we discovered and the positive impact of activating the ICT use in business processes confirm the expediency of implementing the strategy for ICT development as a factor that, through GDP growth, increases the financial and economic capacity. Therefore, it is a variable increasing the national security of the country, which is a particularly topical task for Ukraine given the present stage and unique features of its development.

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[1] the current level of the corresponding indicators in Poland is adopted as a predicted value, taking into account that the target indicator set by the Strategy of Information Society Development of Ukraine is reaching the 50th position in the respective ratings – as of 2017, Poland has got this position