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SOME APPROACHES TO EVALUATION MACROECONOMIC EFFICIENCY OF DIGITALISATION

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Abstract. *Purpose* – the purpose of the article is to study the effect of digitalisation development indicators on per-capita GDP growth.

Research methodology – the basic research method is the fixed-effects panel regression that describes the effect of the digitalisation development indicators on per-capita GDP between 1999 and 2017.

Findings – research showed the most critical factors for per-capita GDP growth are the ones that linked with fixed and mobile subscriptions.

Research limitations – The limitations of the research stem from the limitations of analysis as the method that has been employed makes it possible to measure the effect of the selected variables on per-capita GDP, but further research requires a detailed analysis of the factors being studied in application to each country.

Practical implications – The findings can be used as a basis for choosing areas of more detailed factor analysis of the digitalisation process effectiveness and can support investment decision-making.

Originality/Value – The study enables one to identify the most and the least important factors that are reflected by digitalisation indicators that have an impact on the per-capita GDP.

Keywords: digitalisation, Industry 4.0, new industrialisation, high technology exports ICT technologies.

JEL Classification: O11, O33, O57.

Introduction

The civilised world is entering a new phase of development that is focused on the consumption of products of the fourth industrial revolution: nanotechnology, biomedicine, information technology and cognitive science. The new technical and technological conditions create a new living environment. At the present stage, the most common ones are digital

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technologies that form the basis for information and cognitive technologies which drive the overhaul of industrial production and services.

Over the past few years, digitalisation as a category and a process has been researched in various areas of science, hence the different criteria assigned to the concept. Placing digitalisation in the socio-economic context, many scholars agree that the process will be accompanied by a transformation of the economic model (Negroponte, 1995; Tapscott, 2014).

There is some approaches to defining the new model of socio-economic development. The most common ones are Industrie 4.0, neo-industrialisation, network economy, and the digital economy. There is, however, no single term to describe it yet. Nor has a recognised model for assessing the economic effects of the introduction, growth, and development of digital technologies been presented to the public yet. At the same time, the last few decades have seen plenty of studies in the subject of the impact of digital transition on specific industries and various processes in the economy.

A review of the literature shows methods that are in use today, usually assess the impact of digital technologies on labour productivity growth and employment. In recent years, several authors have studied the impact of digitalisation on GDP, including per capita GDP. However, their research focused on digital empowerment (Evangelista, Guerrieri, & Meliciani, 2014).

This study aims to investigate the effect of indicators defining the level of the development of digital technologies on per-capita GDP growth as an integral macroeconomic indicator of the development of a national economy adjusted for population size.

In line with the above, the following tasks were designed:

- review the existing indicators that measure the penetration and advancement of digital technologies in the economy and the techniques that are employed to assess them;
- select countries for analysing and evaluating the impact of factors influencing the development of digital technologies on macroeconomic indicators and substantiate the choice;
- analyse the impact of some indicators describing digitalisation on per-capita GDP and evaluate the results.

Our search for a research method that would suit best our objectives led us to the panel research method that makes it possible to reveal a link between the dependent variable (per-capita GDP) and independent variables describing digitalisation and to evaluate their importance. We would like to note that this article presents only one segment of a much broader study in terms of its goals, tasks and methodology. We, however, believe that this segment is significant because it reveals the link between the resulting indicator – per-capita GDP that is internationally recognised as an integral macroeconomic indicator – and the regressors under study. Considering the fact that today countries, industries and enterprises are in different starting positions on the path to digitalisation and that there is no internationally recognised measure of the economic effect of digital technology adoption and development, we do not at the present time propose a method of comprehensive integral assessment of the socio-economic effect of the digital transition. We examine the impact of digitalisation factors on the national economic development indicator with consideration for demography.

Our contribution at the present stage is the identification and study of the impact of the key indicators that describe the advancement level of digitalisation on per-capita GDP growth not only at this moment but also over some time. This assessment enables one to identify the most and the least significant factors concerning the countries being analysed and allows for more detailed analyses to be carried out later.

The paper is structured as follows:

The first part of the article presents an overview and analyses of earlier research on the subject of the effect of digitalisation on national economies. Part 2 covers the methodological aspects of our study, explains the principle of grouping the selected countries for the purposes of the study, and describes the variables and the econometric model being used. Part 3 presents the results of the econometric study for three highlighted groups of countries and their analysis and the outlook for digitalisation in individual countries.

The conclusion part summarises the key findings of the research and final observations and makes suggestions for future research.

1. Previous research

In the contemporary literature, various terms have been coined to refer to processes accompanying the adoption and development of information and communication technology such as "knowledge-based economy", "borderless economy", "network economy", "digital economy", Industrie 4.0. Some of these terms describe specific processes in the economy, some describe structural changes, and the other characterises evolving needs.

Emerging electronic markets cause new approaches to management (Grewal, Chakravarty, & Saini, 2010). Under the influence of new technologies and the Internet, the business environment is transforming. In commerce, the share of e-commerce is growing (Davidavičienė, Paliulis, Sabaitytė, &Davidavičius, 2016). The increasing importance of Internet marketing for both the B2B and B2C sectors is explained by the development of electronic markets, an increase in the number of new generation consumers (Sabaityte & Davidavichiene, 2018). Success in this area requires new specific knowledge (Raudeliūnienė, Davidavičienė, Tvaronavičienė, & Radeckytė, 2018). The development of e-business is directly related to innovative activity in the commercial sector, financing, development of legislation protecting property rights, consumer rights, etc. (Kunešová & Eger, 2017). The term "knowledge-based economy" is used to comprehensively define the above processes. The knowledge-based economy is a type of economy that focuses on the creation of smart products that reduce labour intensity and in which intellectual property is regarded as one of the most valuable resources and commodities (Kefela, 2010; Stepaniuk, 2017).

The term "Industry 4.0" got wide acceptance after the German government published The Plattform Industrie 4.0 – an updated industrial development strategy – in 2012. The action plan defines the transition to Industry 4.0 as a reflection of the concept of the digital transition of products and services that implies the shrinking of manual labour. The term "Industry 4.0" is often considered as a synonym of "the fourth industrial revolution". Some authors (Schwab, 2017) define Industry 4.0 as a process of fully automated digital production managed by smart systems in a real-time mode in constant interaction with the external environment. Such production goes beyond one company and has the capacity for merging into a global industrial network of Things and Services. Cetrulo and Nuvolari (2019) address Industry 4.0 as a complex and long-run process of transformation based on the development and strengthening of ICT technologies. While respecting the authors' approach, we shall propose a slightly different interpretation of the category "Industry 4.0". We define it as an integral model that is based on the convergence of nanotechnology, biomedicine, information technology and cognitive science (NBIC). That is why the digitisation of production is only one of the critical elements of the new model and does not fully reflect the essence of the new revolution in science and technology.

The term "digitalisation" refers to the process of digital transformation (Polozhikhina, 2018) as a process of the transformation of information into a digital form at the global level and predominantly in all spheres of activity. The goal of digitalisation ist o reduce costs and provide new opportunities to the entire population. Digitalisation is the backbone of the fourth industrial revolution (Porokhovskiy, 2019). Digitalisation is a wider-embracing concept that also covers the transformation to a digital economy.

In the present-day context, the term "digital economy" has various definitions. Some scholars use the term to denote the growing role of digital information and digital technology in all spheres of economic activity (Tapscott, 1995; Negroponte, 1995). Others interpret digital economy as a convergence of communication, computing and content (Evangelista et al., 2014). Some researchers estimate the number of materials published online on the subject of digital economy at several dozen million, but they can be divided into two groups – those exploring the subject of "digital economy" and focusing on "digital economics" (Polozhikhina, 2018). The digital economy is a type of economic activity. It was officially declared in Russia that digital economy is a particular system of economic, social and cultural relations, implemented through the use of digital ICT (Kapranova, 2018). In our research (Stremousova, & Buchinskaia, 2018), we used the terms "digitalisation" and "digital economy" as non-conflicting.

At the same time, researchers have identified both positive and undesirable or non-beneficial impacts of digitalisation on society or production. For example, Berghäll (2016) supposes that digitalisation does not matter much for spurring innovation in SMEs.

Innovation in small businesses is already quite intense in terms of research and development activities so technological changes requiring additional investment would hinder research and development. Hirsch-Kreinsen (2016) posits that intelligent production systems might have limited prospects because there are technical, economic and social barriers that are difficult to overcome. Pfeiffer (2017) argues that there is no single Industrie 4.0. It is hard to say which innovations will be adopted, which companies will benefit from that innovations since it depends on the specific factors including but not limited to the degree of automation, product complexity, value chains, and production technology. According to Klimova et al. (2018), some segments of the population are not ready to use new technologies. Kovacs (2018) highlights the negative consequences of the transition to Industry 4.0, such as cybersecurity issues, less attention to qualitative than quantitative indicators, and the transformation of labour and investment markets.

Such conclusions raise doubts about the pressing need for and possibility of the development of digitalisation and a transition to the digital economy as a whole and in individual countries. In this regard, it is necessary to estimate the effectiveness of digitalisation processes and determine the potential for transforming a country to the conditions of a digital economy. There is sufficiently large number of methods for testing the digitalisation. Most of them are based on the definition of an integral indicator characterising the development of digital technologies and their impact on the economy. The integral indicator is presented in the form of an index that enables one to build a ranking scale. The most common are the methods of calculating are the Digital Evolution Index (DEI), Information and Communication Technology Development Index (IDI – ICT Development Index), Digital Economy Country Assessment (DECA).

The ITU (International Telecommunication Union) has developed and introduced the ICT Development Index (IDI), a composite index that measures the accessibility of the internet and communication technology (Kravchenko, Bobylev, Valieva, & Fedorov, 2013). The annually measured index shows that nearly 50% of the world's population has internet access, but not all of them are active internet users. In developed countries, lack of or inadequate ICT skills are a significant impediment for people to access the Internet. In developing countries, lack of adequate telecommunications infrastructure and high cost of ICT services prevent more extensive use of the internet (Biggs, 2017).

The ICT Development Index (IDI) is calculated as a combination of 11 indicators that reflect access to ICT infrastructure, availability of internet devices and internet literacy skills. The index has proved useful as an instrument of comparative analysis at a global, regional and national level (Dobrota, Jeremic, & Markovic, 2012).

A large number of methods has been developed internationally to evaluate the development level of digital technologies and their impact on the economy. The Digital Evolution Index (DEI) was presented for evaluating the digital development of economies. The index is a composite indicator measuring four drivers that govern a country's digitisation (Chakravorti, Tunnard, & Chaturvedi, 2017):

- supply conditions, such as access infrastructure, electronic payment methods etc.;
- demand conditions that are in most cases determined by consumer behaviour;
- innovation (including the entrepreneurial, technological and funding ecosystems, presence and extent of disruptive forces and the presence of a start-up culture and mindset);
- digital economy institutions and their effectiveness (for example, governance efficiency and government role in business regulation; the legal environment and facilitatory institutions).

The existing methodologies contain plenty of secondary and indirect indicators, which makes it more challenging to calculate indices the process of collecting and processing information is time-consuming. Sometimes methodologies become outdated too soon and require a revision. Even the IDI method had to be updated in 2018 (Koroivuki, 2018). All too often, methodologies of testing the effectiveness of digital economies lack an objectiveness. The DEI, IDI indices have proven to be useful tools for comparative analysis of the development of digital technologies and the market for information and communication services at the global, regional and national levels. These techniques define technical, technological and organisational processes of digitalisation, the share of digital products in GDP but they do not cover the indicators of the economic effectiveness and impact of digitalisation on the economy as a whole.

Loh and Chib (2019) noted the high impact of ICT technology skills on the likelihood of employment in Singapore. It presumes that the employee's ability to use ICT technologies has a double effect on the national economy. It increases the production capacity, and at the same time, it affects the income of the population and, accordingly, its purchasing power. At the macro level, Richmond and Triplett (2018) draw a similar conclusion by examining the effect of ICT on the Gini index. Strohmaier, Schuetz, and Vannuccini (2019) analysed the impact of digitalisation on the Socioeconomic Performance Index, exploring groups of Asian and European countries. The study showed the substantial, albeit the uneven, impact of digitalisation on the economies of the countries studied. However, in this study, it is troublesome to separate the influence of digitalisation on social indicators from the impact on economic development. Digitalisation can also lead to qualitative changes that do not affect GDP estimates; Watanabe, Tou, and Neittaanmäki (2018) provide an assessment of this aspect and propose a change in approaches to calculating GDP.

Recently, remarkable studies have been published in which attempts are made to analyse the impact of digitalisation indicators on GDP. Evangelista et al. (2014) included indicators of development, use, and empowerment of digitalisation in assessing the impact on per-capita GDP; however, in general, the study was more focused on the study of the impact of digitalisation on the process of employment.

G. Karnitis, Virtmanis, and E. Karnitis (2019) present an assessment of the impact of some of the DESI index indicators on GDP per capita. The result of their study was the conclusion that only 7 out of 31 DESI indicators have a significant impact on GDP per capita. However, among the DESI indicators, there are no indicators of ICT trade in goods and services, which suggests that the impact of the export and import of high-tech goods and services on economic development can be estimated.

2. Methodological basis of the assessment of economic effectiveness of digital economy

While appreciating the significance and timeliness of switching the national economy to digital technology, one has to keep in mind the factor of investment efficiency in digitalisation. A fixed-effects regression model was chosen as the primary research technique. We look at this method as a rapid method which makes it possible to highlight significant factors influencing the digitalisation process. For a more detailed analysis of each country, an individual assessment of the influence of significant factors on the dependable variable should be carried out.

This method allows one:

– to use an internationally recognised, available statistical base;
– to reduce the complexity of calculations and time costs.

This technique can be attributed to the rapid methods underlying the subsequent in-depth analysis. The results make it possible to identify the factors that determine the transition to a digital economy, have a high significance for reaching the goals of analysis and to determine insignificant factors, which enables one to determine priority areas of action to focus on.

The hypothesis: the economic effect of digitalisation, characterised by per-capita GDP change, depends on the level of development of information and communication technologies, including Internet coverage, and the level of export and import of ICT goods and services.

At stage one, we had the task of selecting the indicators that reflect the economic efficiency of a digital economy. When dealing with it, we considered the following conditions:

– availability of digital technologies and their competitive advantages in the sectoral market;
– availability of technical means supporting digital technologies;
– trends in the digital services market;
– forms of the state regulation of the industry.

All the above factors except state regulation could be both external and internal.

To produce a general integral estimation of the digital economy the method of panel data models was used. GDP per capita was selected as a predictable outcome.

Among macroeconomic measures that are used to compare countries' development results, gross domestic product (GDP) is widely used as the key economic indicator in any country. It appears reasonable to use per-capita GDP for a transnational comparative analysis because GDP data is easy to find in statistical datasets. Yakunina and Bychkov (2015) analysing the relationship between indicators such as GDP per capita, Human Development Index (HDI), ICT Development Index, showed a high correlation between the ICT Development Index and HDI, which would entail the appearance of the multicollinearity problem in the studied model. In this regard, we chose to use per-capita GDP as an indicator less correlated with the development of ICT technologies.

Additionally, the correlation between per-capita GDP and (HDI) in the groups of countries studied is 0.85–0.88, which shows a very strong relationship between the indicators.

Like any other value indicator, per-capita GDP has certain drawbacks, but it nonetheless serves as one of the commonly recognised integral indicators that measure the volume of all final goods and services produced in an economy per capita per year.

GDP illustrates the per-capita cost of goods and services produced in a country and is a measure of the development of the national economy. It is also one of the three indicators of quality of life. A country's self-sufficiency in terms of digital technology and digital equipment is determined by the level of digital imports and exports, which means net digital exports of digital goods and services have an impact on per-capita GDP. The accessibility of modern communication means is a factor of their availability in the domestic market, the possibility of their daily use and maintenance, and the capacity of economic agents to purchase and use these means of communication.

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Per-capita GDP can, therefore, help measure the impact of information and communication products on the development of the national economy through the following indicators that are used as input variables:

- Mobile is Mobile cellular subscriptions (per 100 people);
- CommunicationsexportBoP is Communications, computer, etc. (% of service exports, BoP);
- CommunicationsimportBoP is Communications, computer, etc. (% of service imports, BoP);
- Computerservicexp is Computer, communications and other services (% of commercial service exports);
- Computerserviceimp is Computer, communications and other services (% of commercial service imports);
- Fixedsubs is Fixed broadband subscriptions (per 100 people);
- ICTservexportsDoll is ICT service exports (BoP, current US$);
- ICTgoodsexports is ICT goods exports (% of total goods exports);
- ICTgoodsimports is ICT goods imports (% total goods imports);
- ICTserviceexp is ICT service exports (% of service exports, BoP).
- GDPpercap is GDP per capita (current US$).

An analysis of the model showed that it would be optimal to use logarithm functions of the selected variables. Consequently, the model can assess the impact of the incremental growth of the variables on per-capital GDP growth. Clusterization of the data by indicator was done using statistical reports by the World Bank for the period 1999–2017 in 28 countries (World Bank, 2019).

As the study de facto aims to assess the impact of digitalisation on economics, the criteria for selecting the countries are the size of their population and the level of economic development characterized by GDP per capita. Table 1 presents three groups of countries that were selected for analysis.

Table 1. Groups of countries selected for analysis, by population size in 2017 (World Bank, 2019)

Group 1			Group 2			Group 3		
Country	Population, thousand people	GDP per capita, $	Country	Population, thousand people	GDP per capita, $	Country	Population, thousand people	GDP per capita, $
China	1386395	8826	Germany	82695	44469	Netherlands	17132	48223
India	1339180	1942	Turkey	80745	10546	Czech Republic	10591	20368
USA	325719	59531	France	67118	38476	Sweden	10067	53442
Pakistan	197015	1547	UK	66022	39720	Switzerland	8466	80189
Brazil	209288	9821	Argentina	44271	14398	Norway	5282	75504
Nigeria	190886	1968	Ukraine	44831	2639	Singapore	5612	57714
Bangladesh	164669	1516	Poland	37975	13863	Finland	5511	45703
Russia	144495	10743	Australia	24598	53799	Lithuania	2827	16680
Mexico	129163	8910				Latvia	1940	15594
Japan	126785	38428				Estonia	1315	19704

Group 1 consists of countries with the largest population. Among them, only one country – the USA – boasts high values of GDP per capita. Group 2 consists of countries with a population between 20m and 100m. Of them, four countries have high GDP per capita. Group 3 consists of developed countries with a small population and high and very high GDP per capita. Each group was subjected to Hausman Test and Breusch-Pagan Test to discover the best assessment method between the pooled OLS, fixed effect, and random effect panel data estimators. The testing showed that the most appropriate one was a fixed-effect model. Estimation of the impact of regressors on the dependent (result) variable (indicator) in the study can be described by Eq. (1).

$$lnGDP_t = a + b \cdot lnGDP_{t-1} + \sum_{i=1}^{n} c_i x_{ti} + \varepsilon (1)$$

where:

ln GDP_t is the logarithm of GDP per capita in the current year (indicates GDP growth over the period of observation),

t – time period,

ln GDP_{t-1} is the logarithm of GDP per capita over the previous time period (indicates GDP growth in the previous time period),

X_{ti} is the *i*-regressor (exposure) over the current time period,

ε – value of the impact of other factors that are not included in the model;

a, b, c are coefficients:

- a determines the shift of the function;
- b determines the effect of the value of the indicator over the previous period on its current value;
- **c** tells about the magnitude of the relationship between the dependent variable and regressors: the higherr the coefficient, the stronger the relationship.

The fixed-effects model is, therefore, a model of choice for the purposes of quick analysis. The model enables one to choose the resultant (dependent) variable, determine factors that have a certain effect on it and identify factors that will be insignificant with the resultant indicator.

3. Results of quick assessment of socio-economic effectiveness of digital economy

A quick assessment of the effectiveness of the digital economy was conducted for the entire sampling of 28 countries (number of observations equal to 457) and three groups of countries ranked by population (Table 1). Group 1 consists of countries with a population exceeding 100 m. Only two countries in the group – USA and Japan – rank high by the standard of living. For this group of countries, the formula for assessing per-capita GPD growth (Eq. (1)) looks like this (Eq. (2))

$$lnGDPpercap_t = 1.38636 + 0.846579 lnGDPpercap_{t-1} + 0.0183758 lnFixedsubs_{t-1} + \varepsilon \quad (2)$$

The calculation results are presented in Table 2.

Table 2. Results of panel analysis of indicators of information and communication technologies on per-capita GDP growth in countries with largest population (authors' calculations)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
const	1.38636	0.479929	2.889	0.0202**
l_Fixedsubs_1	0.0183758	0.00723249	2.541	0.0347**
l_GDPpercap_1	0.846579	0.0554816	15.26	<0.0001***

Note: *, **, *** Significant at the 10%, 5%, 1% level respectively.

The analysis results show that an autoregressive model in which per-capita GDP growth in the current year is attributed to the GDP growth per-capita in the previous year and the positive impact of the expansion of wired communication networks at 5% has the maximum significance for the countries in this group. The insignificance of other indicators might be due to low quality of life in the countries except the USA and Japan. This hampers the widespread use of information and communication technologies and makes it impossible to increase industrial output through the adoption of software technologies. For example, India is a leading export of IT services, but it is agriculture with predominately manual labour and low wages that makes up a large share of the economy.

In general, the model shows that the calculation results are pretty close to the actual data, especially in the USA and Japan. At earlier stages of the observation, other countries exhibit some deviations from the values that disappear in later years. This is due to the much slower development of broadband internet access in countries with low per-capita GDP.

The analysis of the second group of countries shows that along with the per-capita GDP growth in the previous year another growth variable – Computer, communications and other services – had a low significance of 1%. This variable has a negative impact, which is due to the per-capita GDP growth in these countries is accompanied by a much slower growing, and, in some cases, a decreasing share of computer, communications, and other services in total exports. Widespread use of computer and communication services for personal purposes and commercial and financial deals. This proves the fact that the variable of mobile user growth has a positive impact on per-capita GDP growth with a significance of 5%. Consequently, for the second group of countries Eq. (1) will have the following appearance (Eq. (3)):

$$lnGDPpercap_t = 3.05065 + 0.643094 lnGDPpercap_{t-1} + 0.205753 lnMobile_t - 0.144016\, lnComputerservicexp_t + \varepsilon. \quad (3)$$

The calculation results are summarised in Table 3.

Table 3. Results of panel analysis of indicators of information and communication technologies on per-capita GDP growth in countries with moderate population (authors' calculations)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
const	3.05065	0.613108	4.976	0.0016***
l_Mobile	0.205753	0.0677497	3.037	0.0189**
l_Computerservicexp	−0.144016	0.0349250	−4.124	0.0044***
l_GDPpercap_1	0.643094	0.0744851	8.634	<0.0001***

Note: *, **, *** Significant at the 10%, 5%, 1% level respectively.

The positive impact of mobile communication services and their strong significance in comparison to broadband internet access can be attributed to the fact that in those countries, except Ukraine, people's incomes are relatively high and a large share of the population can afford modern communication means and digital services. The low impact of information and communication technologies in per-capita GDP growth in those countries might be due to the lack of information about large companies and multinationals that apply new digital technologies in production and have subsidiaries that are registered and operate in other countries.

The analysis of the third group of countries indicated the significance of both types of communication services, with the significance of mobile internet services being at 1% and broadband services at 5%. The latter is a sign of stronger dependence. In Group 3 countries, the per-capita GDP growth model (Eq. (1)) is calculated using Eq. (4):

$$lnGDPpercap_t = 2.93333 + 0.602359 lnGDPpercap_{t-1} + 0.228099 lnMobile_t + 0.0411065 lnFixedsubs_t + \varepsilon. \quad (4)$$

The calculation results are summarised in Table 4.

Table 4. Results of panel analysis of indicators of information and communication technologies on per-capita GDP growth in countries with relatively small population (authors' calculations)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	2.93333	0.383879	7.641	<0.0001	***
l_Mobile	0.228099	0.0671415	3.397	0.0079	***
l_Fixedsubs	0.0411065	0.0138351	2.971	0.0157	**
l_GDPpercap_1	0.602359	0.0251797	23.92	<0.0001	***

Note: *, **, *** Significant at the 10%, 5%, 1% level respectively.

The mobile growth indicator and the broadband growth indicator have a positive impact on per-capita GDP growth due to the fact that both people and manufacturing businesses are able to use available digital technologies and do so.

It is worth noting that the coefficients before both variables are more significant than their values found in group one and two; the stronger impact of these indicators on GDP in Group three is due to the fact that in a peaceful situation, countries with small populations that have well-developed manufacturing industries and/or specialize in global financial services that provide a wide range of economic opportunities for business as well as citizens, are capable of adopting new research-intensive technologies both in production and at home. However, the values of the indicator of IT service exports in the balance of payments (in monetary terms) and their share in total exports is lower than in some less developed countries. This is a cause of concern about the national economy's ability to preserve its sovereignty in case of a digital transition because these countries do not export a lot of information and communication products and services produced domestically.

A relatively high coefficient of determination is an indicator of the quality of the applied econometric model. The model delivers a high level of comparability between the calculated and actual indicators across all countries in each group.

The model that has been employed for analysis and forecast shows a clear link between the regressors and the variable being explained. The maximum effect for the growth of per-capita GDP comes from such regressors as ICT exports, the imports of computer, communication and other services as a percentage of the volume of commercial services, mobile phone penetration. At the same time, the analysis shows that the share of exports of ICT services in the cost of exported services grows insignificantly, so it does not have a considerable positive effect on the GDP per capita growth.

The analysis results were used for compiling a ranking of countries for which the share of ICT services exports in monetary value and as a percentage of total services exports has the best effect on the growth of GDP per capita. (Figures 1, 2).

Since 2005, India has significantly outpaced all other countries as the biggest ICT exporter. In 2017, India's ICT exports were nearly USD 8 billion, which is a lot more than other countries' (Figure 1).

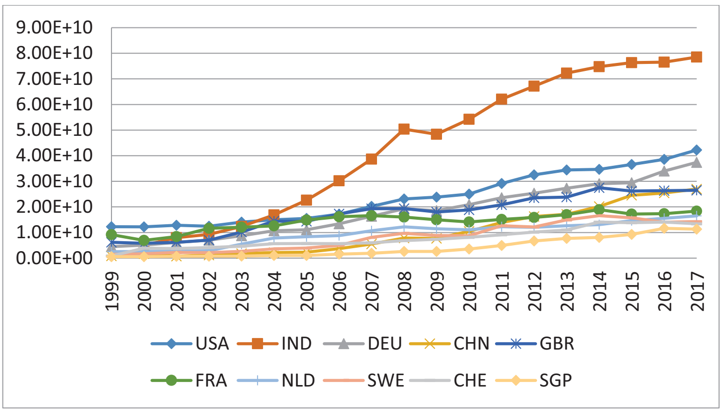

Figure 1. Evaluation of exports of ICT services by balance, in US dollars at current prices (compiled by the authors. Source: World Bank, 2019)

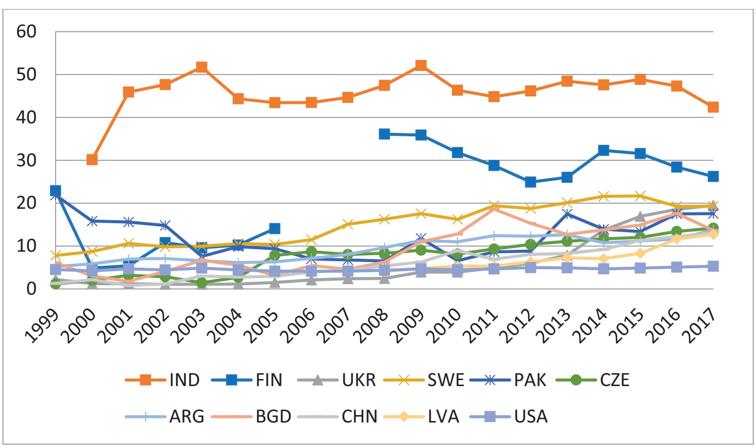

Figure 2. The share of exports of ICT services in total exports of services, % (compiled by the authors. Source: World Bank, 2019)

Some experts attribute the fast-paced development of digital technologies in India to "the size of government procurement in this field. Scientific and technical programs and projects serve as target guidelines for India's state policy" (Biryukova & Matyukhina, 2016).

However, India holds a low spot in the standard of living rankings that rank countries by, among other things, per-capita GDP (Table 1). This might be since India has a much bigger population than other countries (Table 1), while the level of industrial development and employment is not sufficiently high (Stremousova & Buchinskaia, 2018). One can, therefore, assume that India meets its internal demand for ICT services and produces information and communication technologies for export. Starting from 2010 there was an absolute decrease in the share of ICT services in national exports, but the trend is projected to resume in 2019.

In general, the forecasting model of quick assessment of socio-economic return on investment in digital technology proposed by the authors shows that a transition to a digital economy is likely to happen quicker in those countries where there is demand for ICT services. A sustained impact of ICT services exports on per-capita GDP growth also works as a driver of the digital economy because ICT services exports add to national income growth and redistribution, including expenditures on welfare programs.

4. Discussion

The study of some approaches to the assessment of the social and economic effectiveness of the transition to a digital economy has shown that there is still no clear concept of digital economy, nor is there a clear understanding of what makes it different from digitalisation, Industry 4.0 or network economy.

The internationally adopted methodologies for assessing the development of digital technologies are primarily concerned with technical and technological and communication capabilities of national economies. Such globally utilised indicators as DEI and IDI are essential tools for comparative analysis of the progress of digitalisation. These and the DECA methodology help to characterise the technical and technological capabilities of each country to make a transition to digital technology. All the above-mentioned indices do not characterise the opportunities of the transition to the digital economy, and they do not integrate the influence of digitalisation processes, economic opportunities with the results of economic activity. However, techniques that are being designed now or have been upgraded recently contain numerous indirect and secondary indicators. Some of the indicators suggested by the methodologies require score-based assessment. As a result, they are too laborious and not objective enough.

The authors are not aware of any techniques, including quick assessment methods, aimed at assessing digitalisation as an economic process of profit-making.

As our study aims to identify the key factors indicating the future socio-economic effectiveness of digitalisation processes, the authors opted to use a fixed effects regression model as the primary research method. An advantage of the method is that the values of indicators could be retrieved from an internationally recognised and open-source statistical database. The technique allows for the reduction of labour and time costs. The obtained results of indicator processing help identify factors of high significance to the resulting indicators as well as non-significant factors. The analysis of the obtained results enables one to determine priority areas of action for achieving the set goal.

In order to test the method, several countries were selected and divided into three groups by size of their population: countries with large populations, countries that have mid-sized populations, and with small populations (Table 1). The per-capita GDP growth was chosen as a composite indicator that integrates the socio-economic efficiency of economic activity and defines living standards. This technique uses this indicator as the predicted variable. Eight indicators were selected as regressors. The study identified three factors that have the most significant impact on the predicted indicator and factors that have a negative impact on the development of a digital economy in a country. Of the 28 sampled countries, only 10 were found to manifest a high degree of preparedness for the transition to a digital economy.

The research shows that the fixed effects regression model could be employed for carrying out a quick assessment of the preparedness and effectiveness of the transition to a digital economy. For the purpose of drafting national programs and strategies for transitioning to a digital economy, more detailed country-specific factor analysis needs to be performed.

5. Limitations

The analysis method allows researches to determine the influence of the factors studied on per capita GDP growth taken as a critical indicator. However, the evaluation results require further detailed analysis of the factors studied for each country. We also associate limitations with the lack of statistics for some countries over a long period. The development of the international statistical database using unified data processing methods will solve this problem.

Conclusions

Economic digitalisation is an inevitable process in all countries. The tempo of economic transformation into a digital model will determine the further course of economic development in national economies. Therefore, it is crucial to identify factors that influence the process of conversion into the digital economy.This article examines the factors characterising the level of digitalisation, which can influence the indicator of macroeconomic development of the national economy – GDP per capita.

To assess the economic impact of digitalisation on per-capita GDP growth, we used indicators, characterising the type of Internet connections, export, and import of ICT services and goods. Some indicators reflected the actual use of ICT and the Internet, while others reflected participation in the international market.

The primary outcome of this study was the fact, what the most significant factors for per capita GDP growth are the Mobile and Fixed broadband subscriptions. However, indicators of different types of exports and imports of information and communication goods and services do not have a direct effect on per capita GDP.

Thus, the research confirmed our hypothesis only partially: the economic effect of digitalisation depends on the level of development of the Internet connection. The dependence of GDP per capita growth on the level of exports and imports of ICT products and trade has not been confirmed. The possible negative impact on the dependent variable of the indicator of the share of ICT technology exports in total service exports may be explained by a slowdown in the growth of ICT technology exports in several countries. Furthermore, in general, this phenomenon requires further research of this group of countries.

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