Impact of ICT sector deployment on the economic development of the European Union

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IMPACT OF ICT SECTOR DEPLOYMENT ON THE ECONOMIC DEVELOPMENT OF THE EUROPEAN UNION

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Abstract
The information and communication technology (ICT) usage and the digitalization, as the broader implication of ICT deployment, fosters innovation and social cohesion and, over time, becomes an increasingly important driver of economic and social growth. Moreover, the digitalization yield directly to economic growth through the ICT supply side by enhancing the contribution of ICT goods and services in total value added (i.e. production effect). Although the impact of ICT on economic growth and overall development over time become more evident, due to rising in ICT investments and ICT usage, the analyses based on the comprehensive indicators of the economic and the ICT development, still remain open for additional research attention.
In that context, the aim of the paper is to explore the impact of the ICT sector on the development of EU countries. In this research context, the Human Development Index (HDI) was used as an indicator of economic development, that indicate the life quality of individuals in EU countries in terms of their income, the estimated life expectancy and the educational level. Additionally, International Digital Economy and Society Index (DESI) is used as an indicator of the ICT sector development.
The empirical research was conducted on a sample of 28 EU countries. By using a dynamic panel model it was determined that ICT variable influence the HDI of EU countries. Survey results also indicate that broadband Internet usage, individual-level of Internet use and e-commerce use positively contribute to the EU economic development, while the use of e-government services and the increase number of the ICT professionals employed have a negative impact on the same variable. Since the research results provide insight into the areas relevant for economic development the same may contribute and be used as a guideline for development policies at national and sectoral levels as well.

Keywords: Information and Communication Technologies (ICT), Economic Growth and Development, European Union, panel analysis

JEL classification: O10, O33, O52, O57

Introduction

From the historic view, the information availability (i.e. access to information) has been one of the most important drivers of progress and development within societies. According to Janich, Hayot and Pao (2018) the increase in the importance of information transfer and the availability of information greater volume has been recorded long before, in the19th century, and stimulated by (i) an increase in the volume and complexity of public sector and operations, (ii) the emergence of the large scale production systems based on a large-scale economy, and (iii) the development of a social and communication structure.
In the same line, the importance of information has been encouraged by the ICT global international trade growth, as well as the growth of competition and worldwide market liberalization as proved in many national and global economies (Pohjola, 2001; Niebel, 2015). Furthermore, studies indicate that ICT, by fostering innovation and social cohesion, become driver of economic and social development, which over time generate new investments in the ICT sector development (Sepehrdoust, 2018).

Over time, the importance of the ICT issues grows up for both, economies and societies. Consequently, the ICT role extends from (i) *supporting role* to various socio – economic processes like: the education (Fu, 2013; Garbin Praničević, Spremić and Jaković, 2019), the health system (Berg, Aarts and van der Lei, 2003, Haluza and Jungwirth, 2015), public services (Cordella and Bonina, 2012), the life quality and transparency (Trushell, Byrne and Hassan, 2013, Deb, 2014), etc., to (ii) *strategic role* particularly fostered by the perception of the ICT as the source of productivity and innovation in the economic crisis (Alfirević, Garbin Praničević and Ćukušić, 2010). Although the ICT sector does not generate *a priori* revenue and does not always has a positive impact on the development, the ICT usage becomes in time cause more positive impacts on the economic growth (Ceccobelli, Gitto and Mancuso, 2012; Khoung, 2011). Anyhow, there are still no unambiguous attitudes referring how ICT and related investments affects the growth and development of a particular country.

Following above mentioned, this research based on EU countries sample should contribute to the up to date body of knowledge. The related research question is: *which segment of the ICT sector needs to be improved in order to stimulate positive influence in EU economies?* To face with such research challenge, the relationship between the Digital Economy and Society Index (DESI) and the Human Development Index (HDI) is empirically analysed.

Accordingly, the text bellow comprehends: (i) the aspects of ICT understandings and ICT perspectives in EU, (ii) the relationship between the ICT and the economic growth & development complemented with the relevant indicators, (iii) set hypotheses, (iv) the research methodology and (v) the research model specifies. The discussed findings and the conclusion are enclosed at the end.

ICT general overview and ICT perspectives in EU

The construction of the ARPANET network in the mid of 20th century, conceptually and practically, is considered as the start point of the ICT sector development (Shrum, Benson, Bijker and Brunnstein, 2007). The network, mission and goals, were: (i) to reduce labour costs by using computers, (ii) to enable scientists to share resources (such as specialized hardware, software and data), and (iii) to strengthen the scientific community by allowing scientists the closer collaboration. Intriguingly, from the ICT development beginning until

nowadays there was no unique definition of the acronym ICT, mainly due to various ICT usages and the complexity of such implications. The ICT usage and its perceptions differ by sectors but generally the ICT "cover" devices and infrastructures that facilitate the transfer of information through digital means (Zuppo, 2012). Accordingly, the ICT perceptions mainly refers on: (i) network components, applications and systems that enable users to innovate through interaction with the digital world (Hilty and Aebischer, 2015); (ii) an integration of ICT issues, such as business software, data warehouses, mobile wireless technologies, cloud computing, etc. that enable access, store, transmit and manage information worldwide (König, Närman, Franke and Nordström, 2011) and (iii) the infrastructure that includes the named components that underpin up to date computing (Rouse, 2017). Apart from that, the ICT is also perceived as a social capital designed for the knowledge sharing (Hendriks, 1999, Van den Hooff, de Ridder and Aukema, 2004, Becerra-Fernandez and Sabherwal, 2008).

It seems that the variety of terms used to describe ICT concepts and practices is a reflection of the relevance of understanding the broader digital environment and as such stress the need for digital flexibility. In other words, although not each ICT interpretation is straightforward, it is undeniable that the ICT use leads to the business digitization, which entails the complete transformation of business through the continuous learning and innovation of business models, business processes and products (Spremić, 2017). In addition, it is worthy to emphasize the increasing benefit of *the green* ICT application, which refers new mode of ICT usage with respect to sustainable concept as base for future economic growth and development (Suryawanshia and Narkhedeb, 2015).

An insight into the state of the ICT sector in EU countries reveals ICT's significant role in the development of the country's economy, especially the ICT support to EU economy competitiveness on the international market. The same is encouraged by the Digital Agenda (DA) implementation (the Official EU 2020 strategy issue) and associated development goals for EU countries by 2020 (European Commission, 2019). Considering the DA objectives such as: (i) achieving a digital single market, (ii) improving interoperability and standards, (iii) enhancing online trust and security, (iv) promoting worldwide high-speed Internet access, (v) investing in research and innovation, (vi) promoting digital literacy, skills and inclusion; and (vii) harnessing the benefits provided by the ICT sector for EU citizens, it can be claimed that the potential and the perspectives of the ICT sector in EU countries are highly recognized and therefore supported from the national levels.

The ICT, economic growth and economic development: the relationship and the indicators

Various studies exploring the relationship between ICT sector and the economic growth and development, resulting with different findings namely: (i) general insights referring explored relationship globally (Maldoom, Marsden, Sidak and Singer, 2005, Cartelli and Palma, 2009; Nashab and Aghaei, 2009; Bankole, Shirazi and Brown, 2011), (ii) findings relevant for EU countries only (Rohman and Bohlin, 2010, Cortés and Navarro, 2011; Laitsou, Kargas and Varoutas, 2017), and (iii) comparison results indicating that the positive effects of ICT on the economic growth and productivity in EU lag behind the US countries (van Ark, 2002, van Ark, Inklaar and McGuckin, 2003; Daveri, 2004; McCauley, Lofthouse, Kekic and Kenny, 2004; Timmer and van Ark, 2005; van Ark, O'Mahony and Timmer, 2008; Inklaar, Timmer and van Ark, 2008).

Moreover, for proper understanding the mentioned concepts some clarifications ought to be done. Namely, the concept of socio-economic growth is distinguished from the concept of economic development. Economic growth is a shift in quantity and presents a quantitative change reflected in physical indicators, such the rise in employment and investment (Todaro and Smith, 2003). According to Amaedo (2019) economic growth is considered as an increase in the production of goods and services over a given period measured through different indicators, mainly quantitative ones such as Gross Domestic Product (GDP), Gross National Product (GNP) and Gross Domestic Product (GDP) per capita. On the other side, the economic development concept's features are: (i) it is created within the economic system; (ii) it appears in discontinuity, and (iii) it leads to significant qualitative changes, namely working and business conditions, resulting in new equilibrium conditions (Schumpeter, 1982). Development is therefore a process of complete structural change in society, while growth is only a component of development and one of its many drivers.

Regarding related indicators, the most commonly used indicators of economic development in mentioned studies are the gross domestic product and the gross national income per capita (Bankole et al. 2011; Cortés and Navarro, 2011; Laitsou, et al. 2019). Furthermore, the indicators of the ICT sector development referred as above are like: the availability of broadband Internet by country (Maldoom et al., 2005), the application of e-learning and related concepts in the education (Cartelli and Palma, 2009) and the share of internet sales and R&D investment in ICT sector (Cortés & Navarro, 2011). According to Bankole et al. (2011), the impact of ICT sector on economic development varies by countries and depends on many factors. Those factors are the level of economic development, the level of household income, the market situation, etc. The empirical results of numerous studies (van Ark, 2002, van Ark et al, 2003, Daveri, 2004; McCauley, et al. 2004; Timmer and van Ark, 2005; van Ark et al., 2008; Inklaar et al, 2008) pointing out that the increase in ICT development produces the added value, in the US, but not in EU countries.

Although the importance of quantitative growth indicators remains indisputable, the same ones often cannot explain and measure developmental outcomes occurred simultaneously in different spheres of social life, in a particular country and under the particular circumstances. In that context, as the qualitative shift in this research the authors argued the use of more comprehensive indicators of the economic and the ICT development.
On the same line, as complex (composite) indicators of economic development (Klugman, Rodríguez and Choi, 2011) often and recently used are: Global Competitiveness Index (GCI), Human Poverty Index (HPI), Physical Quality of Life Index (PQLI), and also one of the almost most commonly used Human Development Index (HDI). The last HDI is a composite index comprising three sub-indices: (i) the index of life expectancy according birth, (ii) an educational index measured by the mean of the duration of education or the expected duration of education, and (iii) the standard of living measured by gross national (or social) income per capita (PPP US $) (Conceição, 2019).

As an indicator of the ICT sector development and as the factor of the countries' economic development is used the Digital Economy and Society Index (DESI). The DESI compares EU countries with other countries with respect to five key digital economy dimensions, and as such illustrates the ICT sector complexity. The DESI has been established by the European Commission with intention to: (i) originate the transformation of society from analogue to digital, (ii) increase the growth potential of the European digital economy, (iii) monitor and evaluate annually the development of key dimensions (5 in total) of the digital economy in

EU countries and (iv) bring closer to population the purpose of necessary reforms that precede the digitalization of the economy.
The key 5 related dimensions are: (i) connectivity (an indicator of the implementation of broadband infrastructure and its quality), (ii) human capital (an indicator of the skills required to use the digital technologies), (iii) use of the Internet (an indicator of online services use such as on-line content, video calls, online shopping and banking), (iv) integration of digital technology into the business (indicator of e-commerce use versus to the whole business), and (v) digital public services (indicator of public services digitization, namely e-government and e-health) (European Commission, 2019).

Research framework: variables, hypotheses and methodology

Research variables and hypotheses

Based on all above elaborated, the dimensions of DESI are used as the independent (explanatory) variables, while the HDI presents the dependent variable. The research variables in details are enclosed in Table 1.

Table 1: The research variables specifications

Variable	Indicator	Variable Type	Abbreviation	Expected Sign	Source
Human Development Index	The main indicator of economic development within the country	dependent	HDI	/	HDR[64]
Broadband Internet	% of households using the broadband internet	independent	HousUsBro	+	Eurostat
ICT professionals employed domestically	No of ICT professionals employed (in 000) in total employment	independent	ICTemploy	+/-	Eurostat
Internet usage per individual	% of people (Internet users) within the country	independent	IndUsInt	+	Eurostat
the use of e-commerce in the enterprise	% of enterprise using e- commerce	independent	EnterprECOMMpurch	+	Eurostat
E-government	% of individuals using government services	independent	Egovermen	+/-	Eurostat

Source: Authors' research output

Furthermore, with the intention to analyse the impact of ICT sector on the economic development of EU countries, the main and ancillary research hypotheses are defined as follows:

H1: There is a statistically significant impact of the development of the ICT sector, expressed through the selected indicators, on the economic development of EU countries.
H1a: All these indicators have a positive impact on the economic development of EU countries.

Research methodology

[64] UNDP: Human Development Data (1990-2018) retrieved from **http://hdr.undp.org/en/data**

There are several advantages of panel data methodology in empirical analysis when it is crucial to analyse available time series data and space data i.e. countries, firms or even individuals. According to Škrabić Perić (2014) panel models allow for larger number of explanatory variables, larger sample of countries, longer time periods under analysis and greater complexity in the relationships between selected model variables. One of the most important advantage is that panel data modelling allows for the control of heterogeneity in the sample, while there is also possibility to relax the assumption of independence and homoscedasticity with the use of appropriate estimator (Višić and Škrabić Perić, 2011).
Considering the sample characteristics in this research, and the dynamic nature of the control variables, the model specified for this research is dynamic panel data model presented with the following formula:

$$HDI_{it} = \mu + \gamma HDI_{i,t-1} + \beta_1 HousUsBro_{it} + \beta_2 ICTemploy_{it} + \beta_3 IndUsInt_{it} + \beta_4 EnterprECOMMpurch_{it} + \beta_5 Egovermen_{it} + \alpha_i + \varepsilon_{it}$$
$$i = 1,2,\ldots,28, t = 2011,2012\ldots,2017$$

where i=1, 2…, N counts for each country in the panel and t=1, 2…, T states the year of the analysis. Besides, μ refers for an intercept; γ is a parameter of lagged dependent variable and β1, β2, β3, β4, β5, β6 denote the parameters of exogenous variables. It is assumed that ε_{it} are IID (0, σε 2) while α_i represents the unobservable individual-specific effect that is time invariant and it accounts for any individuals.

Research findings

Descriptive statistics

Descriptive statistics of the data is presented in Table 2.

Table 2. Descriptive statistics

Variable	Ar.Sred.	Stand.Dev.	Min.	Max.	I	N
HDI	0.8745	0.0385269	0.782	0.938	28	196
HousUsBro	0.745051	0.1286956	0.5571429	0.9071429	28	196
IKTemploy (u tis.)	267.5566	383.4336	5.4	1619.6	28	196
IndUsInt	0.742402	0.1589218	0.5467842	0.9472677	28	196
EnterprECOMMpurch	0.312602	0.1788019	0.1	0.6314286	28	196
Egovermen	0.4804592	0.1850746	0.1171429	0.8542857	28	196

Source: Authors' research output.
Note: all tests done in this paper are run in the statistical software package Stata 14.2.

The Table 2 indicate that the average value of HDI in EU-28 countries is 0.8745. Given that the maximum number of index is 1, it can be confirmed that EU countries have a high level of index of human development, that is, the overall quality of life in these countries is on average high.
The next step is to interpret each independent ICT variable. The first of these is the percentage of households that use broadband internet. On average, about 75% of households use broadband, where the least-used country has broadband coverage of about 56%. Next variable is the share of employed professionals in ICT relative to the total population, and it was on average around 3.4%. Variable internet use per individual has shown that on average about

74% of EU-28 residents are using the internet, with the smallest share of 55% in the total population, and the highest at about 95%. The next indicator is the percentage of e-commerce in enterprises, which averages around 31% in EU-28 countries, with the lowest being 10% and the highest around 63%. Finally, the use of e-government services per individual is about 48% on average for the sample countries, where the lowest value is about 11% and the highest is about 85%. Thus, the variation in explanatory variables could explain the different levels of HDI for the countries in the sample.

Testing hypothesis and findings overview

To run panel data analysis, and to estimate the model properly, the multicollinearity among independent variables has to be checked. Thus, a pair wise correlation matrix is calculated revealing if there is a multicollinearity problem in the model. Multicollinearity is the occurrence of high intercorrelations among independent variables in a multiple regression model, and it can lead to distorted or unreliable results when determining how well each independent variable can most effectively predict a dependent variable in a statistical model. Furthermore, multicollinearity can lead to wider confidence intervals and less reliable probability values (P values) for independent variables (Kenton, 2018).

Table 3. Pair wise correlation matrix

Variable	HDI	HousUs~o	IKTemploy	IndUsInt	Enterp~h	Egover~s
HDI	1.0000					
HousUsBro	0.6660	1.0000				
IKTemploy	0.4316	0.2963	1.0000			
IndUsInt	0.4879	0.3702	0.0133	1.0000		
EnterprECO~h	0.5852	0.4051	0.3075	0.2837	1.0000	
Egoverment~s	0.7233	0.6102	0.0610	0.5642	0.3828	1.0000

Source: Authors' research output

Table 3 presents the overview of the degree of correlation between the model variables. The highest degree of correlation is between the variables: use of e-government services and the number of households using broadband, which is approximately 0.6. However, according to Gujarati (2009), a serious multicollinearity problem does not occur until these numbers exceed the value of 0.8, so it can be concluded that there is no multicollinearity problem in the specified model.
Finally, using statistical software Stata 14.02, the model of determinants of HDI is estimated using Blundell-Bond estimator and presented in Table 4.

Table 4. Estimation results

Variable	Model HDI
L.HDI	0.979***
	(0.0187)
HousUsBro	0.00451***
	(0.000922)
IKTemploy	-0.00000193***
	(0.000000647)
IndUsInt	0.000708*
	(0.000392)
EnterprECOMMpurch	0.00156**
	(0.000738)
Egovermentindividuals	-0.00668***

	(0.00198)
_cons	0.0208
	(0.0153)
Number of observations	168
Number of countries	28
Number of instruments	26
Sargan test	0.5762
AR (1) -p value	0.0809
AR (2) -p value	0.5417
The brackets contain standard error values * p <0.1, ** p <0.05, *** p <0.01 - Interpretation of statistical significance	

Source: Authors' research output

Table 4 shows the results of the model as well as the results of the Sargan test and the first and second-order serial correlation test. As the methodology requires, before analysing the model results, diagnostic tests of model validity are performed. For this purpose Sargan test and tests for serial correlation are used. Additionally, when conducting a panel analysis, it is always necessary to check the number of instruments used. According to Roodman (2009), if the number of instruments exceeds the number of observations (in this case the number of countries observed), the estimator will become biased and the Sargan test may mislead the model of endogeneity.
This is not the case in this model, since the number of instruments is 26 and the number of countries is 28. This proves that the model is not biased, and a Sargan test value of 0.5762 approve that there is no endogeneity problem in the model, since the p-value of this model is higher of 0.05.
For serial correlation in dynamic panel data, Arellano and Bond (1991) derived two tests: test for the first-order serial correlation (labeled AR(1)) and the test for the second-order serial correlation (labeled AR(2)) in differenced residuals. Null hypothesis of both tests posits that there is no serial correlation and no misspecification of the model if there is no second-order serial correlation. Since p-value of AR (2) test in the specified model is 0,5417, the null hypothesis test is not rejected. Finally, since the lagged dependent variable is less than 1, positive and statistically significant, the stationarity condition is fulfilled and the use of a dynamic panel model in this paper is justified.

After validation of the model, it is necessary to interpret the results obtained in the model and confirm that they are in line with the expected results. The first explanatory variable is the **percentage of households using broadband Internet**, or broadband. Costa (2016) outlines three main ways in which this variable can contribute to economic growth: (i) better access to global labour markets, (ii) increased workplace productivity and (iii) increased GDP growth, due to the business processes improvement, innovation fostering with new customer applications and services, and improving the business efficiency.

The second explanatory variable within the model is **the number of ICT professionals employed domestically**, and its impact on economic development is negative. This can be explained by the fact that investing in the education and training of people to become an ICT professionals is a long and expensive process and that it takes long time (than it was encompassed in this paper) to turn this contribution into a positive influence. Furthermore, another possible explanation is that once these workers finish education and training, they decide to move out of the country where they were educated, thus making the negative balance of the government investment in education (OECD, 2001). Therefore, if the number of people employed in ICT industry is growing on a yearly basis, this brings a higher cost to the country with negative investment balance in the education in ICT, because it means that

ICT workers come from abroad. Lastly, as this sector is profitable and offers the opportunity to make good profits, people from other sectors tend to work in ICT, creating redundancies in ICT, and a shortage of employees in other sectors. Consequently, the labour market imbalances occur, which negatively affects counties' economic growth.

The third explanatory variable within the model is **internet usage per individual**. This variable contributes positively to economic development, and according to Manyika and Roxburgh (2011), there are three main reasons for this: *strong contribution to GDP growth due to the rise of online trade*, *the improvement of the living standards* and *constant promotion of business transformation and economic modernization through internet.*

The fourth explanatory variable relates to **the use of e-commerce within the enterprise**, and it has a positive impact on economic development. Albăstroi (2007) screened several aspects of this variable, which could promote and give values to economic development, such as *enabling businesses to sell goods and services in international markets* (thus empowering international transactions) not only in domestic ones; *creating new opportunities for SMEs to participate in international and/or global trade* and *encouraging the process of economic activities fragmentation.* Thus, e-commerce is becoming an essential mean of counties' integration in the global economy.

The last explanatory variable studied in the model is **the use of E-government services per individual**, and this has had a negative impact on economic development. This can be explained by the fact that in order to achieve e-government services, an individual government need to highly invest in the successful building and implementation of these services, which costs money and time. Since government spending has a negative impact on GDP (Mitchell, 2005) and GDP is one indicator of economic development, it is clear why this variable has a negative impact on it.

The above mentioned confirms that there is statistically significant impact of the development of the ICT sector, expressed through selected explanatory variables (i.e. DESI components), on the economic development of European countries. According to the p-values within the model, it can be confirmed that all variables are significant at values of 1%, 5% and 10%.
Additionally, the results show that out of the 5 explanatory variables studied, 3 of them have a positive effect on the economic growth (use of the broadband, use of the Internet per individual and the use of e-commerce in enterprises), while two variables have a negative impact on economic development (number of ICT professionals employed and use of e-government services). Thus, the auxiliary hypothesis H1a: All indicators have a positive effect on the economic development of the countries studied, should be partially accepted.

Conclusion

This paper has sought to contribute to the raised and ongoing scientific interest on the contribution of ICT industry to the economic growth and development. The research aim was to determine how ICT affect the development of EU countries. Because social aspects are often overlooked when examining the impacts of these variables, research looked at both, social and economic aspects, for a more comprehensive and better account of the situation within EU countries.
To bring the new insights, a not often analysed group of explanatory variables and dependent variable was chosen for the study. Furthermore, this study brought the novelty to the

empirical research by panel model specification, specific time-period under study (2011-17) and data sample, i.e. EU 28 member states.
Due to the breadth of the variables taken into the model estimation, a more realistic picture of the state of economic development in the countries under study was obtained. The findings suggested that at EU 28 level investing in parts of the ICT sector such as broadband expansion, e-commerce growth and encouraging online activities is favourable for economic development. On the other hand, EU countries should start encouraging people to invest their knowledge and resources into their own countries, i.e. to work domestically, as well as to reduce government spending on e-services investments or repurposing them, since the results show the negative effects on economic development.

Finally, the research results can serve as a guide for the further ICT sector development, and for finding ways to improve people's lives due to ICT and to stimulate economic growth in the observed countries. With smart and well-planned development of ICT sector and implementation of its products and services, contribution can be made in areas of life quality for both individuals and nations.

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