ICT DEVELOPMENT AND ECONOMIC GROWTH IN EU TRANSITION ECONOMIES: A PANEL COINTEGRATION AND CAUSALITY ANALYSIS

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ABSTRACT

The globalized world has experienced the substantial improvements in development information and communication technologies (ICT) during the last decades. The aforementioned considerable improvements led many economic and non-economic implications for the countries. This study investigates the influence of information and communication technologies' development on the economic growth in 11 post-transition EU members over 1996-2017 period through panel cointegration and causality tests. The analyses revealed that ICT development positively affects the economic growth in the long run and ICT development and economic growth feeds each other in the short run.

Keywords: ICT, economic growth, panel cointegration and causality analyses

JEL Classification: C33, E22, J24, O30, O47

1.Introduction

The considerable improvements in information and communication technologies (ICT) have led a transformation from industrial societies to the information and knowledge societies. The aforementioned ongoing transition has affected both the society and the economy in different ways. In this regard, the ICT development fabulously eased and accelerated the access and transfer of information and knowledge by all the economic units. In this context, the role of ICT in transforming the world has directed the scholars to investigate economic and non-economic impacts of ICT development.

In this context, one of the most studied issues in the relevant literature is the growth effect of ICT development. The ICT development is expected to positively affect the economic growth through various channels by raising the productivity, making a contribution to innovation and development of new products, decreasing costs for users, raising the financial development in theoretical terms (Andrianaivo and Kpodar, 2011; Niebel, 2018). In this regard, the endogenous growth theory accepts ICT as a contributor to economic growth through leading innovation, new products, business models, and processes (Czernich et al., 2011). Furthermore, ICT sector makes a significant contribution to economic growth by frequent technological

advance, raising product variety, decreasing relative prices and strong demand (Erdil et al., 2009). On the other side, the improvements in economic growth lead ICT development by providing new investments in ICT, while ICT development fosters the growth.

In this study, we explored the ICT development's effect on growth in the sample of EU transition economies considering relevant empirical literature. The EU transition economies embarked on transformations of their institutions and economic systems entirely and covered ground for the integration of global economy. The aforementioned transformation process and the EU full membership process made a significant contribution to ICT development of the EU transition economies as seen in Table 1. The countries liberalized the telecommunication sector and took regulatory measures to raise the competition in harmony with EU policies.

Table 1: ICT Development in EU Transition Economies

Country	ICT Development Index	
	2002	**2017**
Bulgaria	2.74	6.86
Croatia	3.19	7.24
Czechia	3.74	7.16
Estonia	3.93	8.14
Hungary	3.49	6.93
Latvia	3.30	7.26
Lithuania	3.17	7.19
Poland	3.34	6.89
Romania	2.48	6.48
Slovakia	3.51	7.06
Slovenia	4.47	7.38

Source: International Telecommunication Union (ITU), 2009 & 2018

The paper makes a contribution to the existing literature on growth effect of ICT development in two ways; first, it is one of the early studies (to the best of our knowledge) focusing on a sample consisting of 11 EU transition economies. Secondly, it employs the econometric tests yielding relatively more robust results under cross-sectional dependence and heterogeneity. The article explored the growth effect of ICT development in 11 post-communist EU countries by employing a second generation cointegration test and causality test over the duration of 1996–2017. The remainder part of the article is formed as follows: Section 2 sums up the related literature. Section 3 defines the data and analysis method. Section 4 reports and discusses the obtained findings. Section 5 concludes and provides policy implications and recommendations.

2.Literature Review

The worldwide speedy development of ICT for last thirty years has raised concern about economic and non-economic impacts of ICT among many scholars. One of the most researched issue has been growth effect of ICT penetration in various countries with different development levels at micro and macro levels. The large part of the empirical literature disclosed a positive growth of ICT development.

In the early empirical literature, Mankiw et al. (1992) analyzed the influences of ICT development on economic growth in 24 developed and 42 developing countries for the term of 1985-1999 and disclosed that ICT development positively affected economic growth in high income countries, but insignificant in developing countries. Hernando and Núñez (2004) analyzed the concequences of ICT on growth of output and labor productivity in 1300 firms in Spain for the period of 1991-2000 by regression analysis and uncovered that ICT use positively contributed to the growth of output and labor productivity. Erdil et al. (2009) explored the growth of ICT development in 131 countries through dynamic regression analysis and disclosed a positive growth effect of ICT. Nasab and Aghaei (2009) researched the growth effect of ICT investments in OPEC countries for the years between 1990 and 2007 by dynamic regression analysis and put forth a positive growth effect of ICT investments.

Vu (2011) researched the growth effect of ICT in 102 countries for the years covering 1996-2005 through different regression methods and discovered that ICT was a significant positive determinant of economic growth. Andrianaivo and Kpodar (2011) analyzed the influences of ICT on economic growth in 44 African countries for the years from 1988 to 2007 through regression analysis and indicated that ICT had a positive impact on economic growth. Farhadi et al. (2012) investigated the relationship between ICT and economic growth in 159 countries for the term 2000-2009 through dynamic regression analysis and showed a positive growth effect of ICT.

Spiezia (2012) also analyzed the impact of ICT investments of software, computer, and communication on productivity in 26 industries from 18 OECD countries from the period of 1995-2007 and revealed that all the ICT investments positively contributed to productivity in all industries. Hodrab et al. (2016) analyzed the effect of ICT on economic growth in 18 Arab countries for the term between 1995 and 2013 through regression analysis and reached that ICT positively affected economic growth. Pradhan et al. (2017) researched the ICT's short and long run effects on economic growth in 11 countries (Bangladesh, Egypt, Indonesia, Iran, South Korea, Mexico, Nigeria, Pakistan, Philippines, Turkey, and Vietnam) through causality and cointegration tests and disclosed that in the short and long run, ICT penetration made a contribution to economic growth.

Amiri and Woodside (2017) explored the effect of ICT development on economic growth in BRIC countries for the period of 2007-2015 by correlation analysis and indicated a positive correlation between ICT development and economic growth. Albiman and Sulong (2016 and 2017) analyzed the impact of ICT on economic growth in Sub-Saharan African countries for the duration of 1990-2014 by different techniques of panel data analysis and showed that ICT had a positive influence on economic growth. Amaghionyeodiwe and Annansingh-Jamieson (2017) analyzed the indicators of ICT development on the economic growth in Caribbean countries for the period of 1996-2013 through regression analysis and disclosed that ICT development has positive consequences on the economic growth. Aghaei and Rezagholizadeh (2017) researched the implication of ICT investments on the economic growth in OIC countries for the period of 1990-2014 through regression analysis and disclosed that ICT investments influenced the economic growth positively.

Stanley et al. (2018) conducted a meta-analysis to the 58 papers on the nexus of ICT-growth and indicated that ICT generally makes a positive contribution to the economic growth in both developing and developed countries. Toader et al. (2018) explored the growth effect of ICT infrastructure in EU-28 for the term of 2000-2017 by dynamic regression analysis and uncovered a positive growth effect of various ICT indicators.

Niebel (2018) researched the ICT's effect on economic growth in 59 developed, emerging and developing countries during the term of 1995-2010 by regression analysis and revealed a positive growth effect of ICT, but the developed countries obtained more gains from

ICT investments than emerging and developing economies. Majeed and Ayub (2018) researched the effect of diverse ICT indicators on economic growth in 149 countries during 1980-2015 period with different regression analysis techniques and found that the ICT indicators accelerated economic growth. Pradhan et al. (2018) researched the short and long run impact of ICT penetration on economic growth in a panel of emerging growth leading countries for the period of 1988-2012 through panel cointegration and causality analyses and disclosed that ICT penetration had significant effects on economic growth in short and long run.

Bahrini and Qaffas (2019) researched the influence of ICT diffusion proxied by different indicators on economic growth in 31 countries from Sub-Saharan Africa region and 14 countries from MENA region over the period of 2007-2016 through dynamic regression analysis and discovered that ICT development influenced the economic growth positively. Jiménez-García (2019) examined the effect of various ICT indicators on economic growth in Mexico during 1990 – 2014 period through regression analysis and reached a positive growth effect of ICT. Bilan et al. (2019) researched the interaction between ICT and growth in 163 countries in 2017 and found a positive relationship between ICT development and growth. Lastly Adeleye and Eboagu (2019) researched the growth effect of ICT development in 54 African countries for the period of 2005-2015 by regression analysis and revealed a positive growth impact of ICT development.

3.Data and Econometric Methodology

The study investigated the growth effect of ICT development in 11 EU transition economies for the duration of 1996-2017 with panel cointegration and causality tests.

3.1.Data

The dependent variable of economic growth was proxied by growth rate of real GDP per capita of World Bank (2019a). On the other side, the independent variable of ICT diffusion were represented by mobile cellular subscriptions (per 100 people) and individuals using the internet (% of population) and obtained from the database of World Bank (2019b&2019c). All the variables were annual and the relevant data availability led us to determine the study period as 1995-2015.

Table 2: Data Description

Variables	Description	Source
GRW	Real GDP per capita growth (annual %)	World Bank (2019a)
MOBILE	Mobile cellular subscriptions (per 100 people)	World Bank (2019b)
INTERNET	Individuals using the Internet (% of population)	World Bank (2019c)

The sample of the econometric analysis comprised the countries of Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. The econometric analyses were conducted by the software of Stata 14.0 and Gauss 10.0. The key features of the dataset were presented in Table 3. The average economic growth in the sample was about 3.7%. The average of mobile cellular subscriptions (per 100 people) was about 83.7 and the average of individuals using the internet was about 42% of the population. However, both mobile cellular subscriptions and internet penetration varied considerably in the sample.

Table 3: Summary statistics of the dataset *(calculated by the author)*

Variables	Mean	Std. Deviation	Minimum	Maximum
GRW	3.761887	4.163320	-14.55986	13.08145
MOBILE	83.67447	49.30959	0.074543	164.0836
INTERNET	42.00745	27.74822	0.221623	88.40970

3.2.Econometric Methodology

The cointegration relationship between indicators of ICT development, and economic growth was analyzed with the LM bootstrap cointegration test of Westerlund and Edgerton (2007). The test rests on Lagrange test multiplier developed by McCoskey and Kao (1999) and allows autocorrelation and heteroscedasticity in the cointegration equation. Westerlund and Edgerton (2007) cointegration test also prevents the possible endogeneity problem through using fully modified ordinary least squares and yields relatively more robust results for the small samples. The relationship between the variables is derived from (1) numbered equation.

$$y_{it} = \alpha_i + \dot{x}_{it}\beta_i + z_{it} \qquad (1)$$

$$z_{it} = u_{it} + \sum_{j=1}^{t} \eta_{ij} \qquad (2)$$

$$LM_N^+ = \frac{1}{NT^2} \sum_{i=1}^{N} \sum_{t=1}^{T} \widehat{w}_{it}^{-2} S_{it}^2 \quad (3)$$

$$w_{it} = (u_{it}, \Delta x'_{it})' \qquad (4)$$

i and t in the above equations respectively represents the cross-section and time dimensions. η_{ij} is the error term with zero average and σ_i^2 variance. LM_N^+ test statistic is formed to test the hypotheses and w_{it} and S_{it} is the partial sum of z_{it} error terms estimated by FMOLS. The critical values of the test are derived from bootstrapping.

Lastly, the reciprocal interaction among indicators of ICT development, and economic growth was analyzed with Dumitrescu and Hurlin (2012) causality test yielding robust results even under cross-sectional dependency.

4. Empirical Analysis

In the applied section of the article, first the pre-tests of cross-sectional dependence and heterogeneity were conducted. The availability of cross-sectional dependence was tested through LM, LM CD and LM adj. tests and the results of the tests were reported in Table 4. The null hypothesis affirming the non-existence of the cross-sectional dependence was denied at 1% significance level. So the tests revealed a cross-sectional dependence among the series.

Table 4: Cross-sectional Dependence Tests' Results *(calculated by use of the tests)*

Test	Test statistic	P value
LM (Breusch and Pagan(1980))	421.4	0.0000
LM adj. (Pesaran et al. (2008))	82.9	0.0000
LM CD Pesaran (2004)	19.44	0.0000

Furthermore, the availability of heterogeneity was tested with adjusted delta tilde test of Pesaran and Yamagata (2008) and test results were shown in Table 5. The null hypothesis asserting the homogeneity's availability was accepted, because the p values were found to be higher than 10%. Therefore, slope coefficients of the cointegration equation were revealed to be homogeneous.

Table 5: Heterogeneity Tests' Results *(calculated by use of the tests)*

Tests	Test statistic	P value
$\tilde{\Delta}$	-0.691	0.755
$\tilde{\Delta}_{adj.}$	-0.761	0.777

The stationarity analysis of the series was examined with Pesaran (2007) CIPS (Cross-sectionally augmented IPS (Im- Pesaran-Shin (2003)) unit root test paying regard to cross-sectional dependence and the test consequences were shown in Table 6. The test consequences revealed that all of the series except INTERNET were I(1).

Table 6: CIPS Unit Root Test Results *(calculated by use of the test)*

Variables	Constant	Constant + Trend
GRW	-1.726	0.308
D(GRW)	-4.351***	-2.503***
MOBILE	0.074	0.238
D(MOBILE)	-1.835**	-1.281*
INTERNET	-0.450	0.716
D(INTERNET)	-1.403*	-0.862*

Optimum lag length was specified as 2 taking notice of Akaike information criterion, Schwarz information criterion and Hannan-Quinn information criterion.
***, **,* indicated that it is respectively significant at 1%, 5% and %10.

The cointegration relation of economic growth and ICT development indices was tested by Westerlund and Edgerton's (2007) cointegration test considering the availability of cross-sectional dependence and the test results were demonstrated in Table 7. The null hypothesis asserting the existence of cointegration relationship was accepted in two models considering Bootstrap p-values since the cross-sectional dependence was observed through the series.

Table 7: Westerlund and Edgerton (2007) LM Bootstrap Cointegration Test Results
(calculated by use of the cointegration test)

	Constant			Constant and Trend		
LM_N^+	Test statistic	Asymptotic p-value	Bootstrap p-value	Test statistic	Asymptotic p-value	Bootstrap p-value
	-0.365	0.642	0.966	2.385	0.009	0.770

The cointegration coefficients was estimated through use of the AMG estimator of Eberhardt and Teal (2010) taking account of the cross-sectional dependence and the estimated coefficients are displayed in Table 8. The panel cointegration coefficients revealed that mobile cellular subscriptions representing ICT development affect the economic growth positively, but internet usage had no significant impacts on the economic growth.

However, the individual coefficients revealed that mobile cellular subscriptions positively affects the economic growth in Bulgaria, Estonia, Latvia, and Romania. On the other side, internet usage of another ICT indicator positively affects the economic growth in Croatia, Hungary, and Slovenia.

Table 8: Results of Cointegration Coefficients' Estimation *(calculated by use of AMG estimator)*

Countries	Coefficients	
	MOBILE	**INTERNET**
Bulgaria	0.0734715**	-0.029011
Croatia	-0.0076053	0.0670672
Czechia	0.0248444	0.0420661
Estonia	0.1427983*	-0.1542713
Hungary	-0.0101442	0.0623288
Latvia	0.1798451*	-0.1727268
Lithuania	0.0339208	0.0730708
Poland	-0.0251408	0.061335
Romania	0.1162671**	-0.041557
Slovakia	0.0319705	0.0342645
Slovenia	-0.0256621	0.0976056**
Panel	0.0485968**	0.003652

***, **,* indicated that it is respectively significant at 1%, 5% and %10.

The causal relationship between economic growth and indices of ICT development was tested by Dumitrescu and Hurlin (2012) causality test and results of the tests were shown in Table 9. The results uncovered a bilateral interaction between ICT development proxied by mobile subscriptions and economic growth.

Table 9: Causality Analysis Results *(calculated by use of the causality test)*

Null Hypothesis	W-Stat.	Zbar-Stat.	Prob.
DMOBILE ↛ DGRW	**4.81136**	**2.97688**	**0.0029**
DGRW ↛ DMOBILE	**0.85297**	**-1.77838**	**0.0753**
DINTERNET ↛ DGRW	2.24069	-0.11129	0.9114

DGRW ↛ DINTERNET	1.61862	-0.85860	0.3906
DINTERNET↛ DMOBILE	2.30137	-0.03839	0.9694
DMOBILE ↛ DINTERNET	3.46832	1.36348	0.1727

The empirical analyses revealed a mutual interaction between economic growth and ICT development proxied by mobile subscriptions. The aforementioned interactions was consistent with theoretical expectations, because the improvements in economic growth leads ICT development by providing new investments in ICT, while ICT development fosters the growth. The long run growth effect of ICT development proxied by mobile subscriptions was found to be positive and it was consistent with predictions of new growth theories and the findings of extensive empirical literature.

5. Conclusion

The significant improvements in the ICT sector have experienced in the world and rapidly expanded with the contribution of globalization and liberalization processes. The aforementioned developments in ICT sector encouraged the scholars to explore the economic and non-economic effects of ICT development. The growth effect of ICT has been one of the widely researched issues in the relevant literature, but the relevant literature revealed that the growth effect of ICT development has been rarely investigated. Therefore, we researched the short and long run growth effect of ICT development in sample of 11 EU transition economies for the period 1996-2017 through causality and cointegration tests.

The causality analysis disclosed a bilateral interrelationship between economic growth and ICT proxied by mobile cellular subscriptions. On the other side, the long run analysis disclosed that ICT proxied by mobile cellular subscriptions positively affected economic growth. Consequently, both short and long run analyses revealed that ICT development was a significant determinant of economic growth. In this regard, on one hand ICT investment makes a contribution to ICT sector, on the other hand ICT sector development feeds the economic growth through ICT sector growth and raising productivity and promoting the other sectors. Future studies can focus on which channels ICT development contributes to economic growth.

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