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IMPACT OF DIGITALIZATION ON ECONOMIC GROWTH IN E7 COUNTRIES: AN APPLIED APPROACH

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Abstract

The aim of this study is to investigate the impact of digitalization on economic growth in E7 countries using panel data analysis methods with annual data for the period 2003-2021. Information and communication technology product exports, the number of individuals using the internet (% population) and theDi number of mobile phone subscribers were used to represent the digitalization indicator. According to the panel cointegration test results of Gengenbach et al. (2016), there is a cointegration relationship between the variables. Since a cointegration relationship was detected between the variables, the Average Group Dynamic Least Squares (DOLSMG) estimator, which is suitable for models with heterogeneous slopes, was used. According to the DOLSMG long-term coefficient estimation results, there is a positive and significant relationship between the export of information and communication technology products, the number of individuals using the internet and the number of mobile phone subscribers, which represent the digitalization variable for the entire panel, and economic growth. According to the panel causality findings, there is a bidirectional causality relationship between economic growth and information and communication technology product exports in E7 countries. Furthermore, the findings reveal that there is a one-way causality relationship from individuals using the internet to economic growth and from economic growth to mobile phone subscriptions in the E7 countries.

Keywords: Digitalization, Economic Growth, Panel Data Analysis

Jel Kodları: O1, O40, C3

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1. Introduction

Digitalization is defined as the transformation of messages (words, pictures, letters, etc.) created in an analog system into separate signals that can be transmitted, processed, and stored electronically (Ozel and Sert, 2015). The word digitalization can be defined as the digitization of information. It refers to the process of digitizing the obtained data and obtaining it on various platforms. Digitalization can be described as the conversion of analog processes into a digital format by storing them in a computer environment (Karakas et al., 2009). Digitalization has gained tremendous momentum in the last twenty years, radically changing the way people, consumers, and businesses behave, work, and communicate globally. This pattern is attributed to technological progress and the emergence of Information and Communication Technologies (ICT), especially the Internet and mobile phone technologies, which create new products and processes, new market channels, and organizational complexities (Acemoglu and Robinson, 2013).

Information and communication technology products are mostly among the goods with high added value. The export of these products both supports economic growth and creates qualified and high-income employment opportunities (World Bank, 2020). The relationship between information, technology and economy has a complementary structure. Technology has continuously developed by feeding on knowledge accumulation, and each technological innovation has transformed the social structure by creating its own economic systems. While the main element of production in industrial societies is capital, the fact that information has become the leading element in the production process in information societies has made information and technology the leading element of economic growth (Gonel, 2016). The development of information and communication technologies and the innovations that have emerged in parallel also increase the growth performance of economies. Technological innovations have an important role in growth. In the growth theories that have been the subject of various studies in the academic literature, it has been seen that the technology factor is included in both internal and external growth theories (McCraw, 2006). In recent years, the dynamic development of ICT has caused significant changes in almost every area of social and economic life. As a result of this development, the digitalization process has now become a determinant of both progress and modernization (Brodny and Tutak, 2022). Three channels can be mentioned for the contribution of ICT to growth: Information Communication Technologies support both increased use and continuous improvements in performance, so that ICT can be used as a factor of production; ICT production contributes to productivity with very high

advances and its importance has increased in the last few decades; Externalities are taken into account (Cimen and Sunal, 2024: 28). One of the contributions of digitalization to economic growth is its impact on innovation. By enabling entrepreneurs to design and deliver new products and services more efficiently and by expanding their access to wider markets through digital platforms, digital transformation stimulates entrepreneurial activity and market competition. These dynamics collectively increase economic productivity and support sustainable growth trajectories (Chatterjee et al., 2020; Gans, 2016).

The number of individuals using the internet, which is included in the literature as an indicator of digitalization, is also very important in terms of digitalization. The internet is considered one of the basic infrastructures of digitalization and directly affects the participation of individuals in digital services, education, e-commerce and social life. The number of people using the internet not only shows the level of access of a country to digital infrastructure; it is also considered as an indicator of digital literacy, technology adoption rate and the success of digital policies (ITU, 2025; World Bank, 2020; OECD, 2021; European Commission, 2022). In addition, since this data is regularly reported by various national and international organizations, it can be used in comparative analyses on a time and country basis (OECD, 2019).

Another indicator of digitalization is the number of mobile phone subscribers. Mobile phone subscription describes the number of subscribers who access telecommunication services via mobile networks (Adeleye and Eboagu, 2019). Mobile phones are a common tool for internet access and access to digital services. The number of mobile phone subscribers can directly indicate the prevalence of digital access in a country and the participation of individuals in the digital world through mobile devices. The increase in the number of subscribers indicates that individuals' access to digital tools and the potential to benefit from various services using these tools have expanded. For example, it plays an important role in many sectors such as financial services, e-commerce, healthcare, and education. Therefore, the number of mobile phone subscribers is an important variable that evaluates the effects of digitalization on economic and social participation (World Bank, 2021; ITU, 2020).

The term Emerging 7 (E7) refers to the emerging economies that drive global economic growth. These countries are China, India, Brazil, Russia, Indonesia, Mexico, and Türkiye. The term was first coined by PricewaterhouseCoopers (PwC) in 2006 (PwC, 2006). Analysis by PricewaterhouseCoopers (PwC) predicts that by 2050, the total Gross Domestic Product (GDP) of the E7 countries (China, India, Brazil, Russia, Indonesia, Mexico, and Türkiye) calculated

on a Purchasing Power Parity (PPP) basis will exceed the total GDP of the G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) (PwC, 2017).

As developing economies, E7 countries stand out with their labor and natural resource potential and are expected to represent a significant portion of the global economy by 2050 (Irfan & Ojha, 2022; Bekun et al., 2023). In the literature, the economic growth potential of E7 countries is generally associated with strong domestic demand, young population, industrialization progress, and digital transformation capacity (Wilson & Purushothaman, 2003). The demographic size of these countries, the widespread use of digital infrastructure, the increasing role in global supply chains, and the potential for socio-economic transformation create an ideal context for investigating the effects of digitalization on economic growth. Therefore, this study investigates how digitalization affected economic growth in E7 countries between 2003 and 2021. It aims to contribute to the development of the literature in terms of providing new evidence in the context of E7 countries. The second section includes literature examples, and the third section discusses the data set and method. Finally, the results obtained are presented.

2. Literature Review

The literature on digitalization and economic growth attracts considerable attention today. When the literature is examined, we can explain the examples of literature as follows;

If we give an example of multi-country analysis in the selected literature on digitalization and economic growth; Choi and Yi (2009) found that internet use had a positive effect on economic growth in their analysis of 207 countries for the years 1990-2000. Pradhan et al. (2013) examined the relationship between the internet, economic growth, public expenditure and inflation for 34 OECD countries. According to the panel cointegration test, it was seen that the variables were cointegrated. Artan et al. (2014) investigated 17 transition economies using static panel data analysis technique. The findings showed that developments in information and communication technologies positively affected economic growth. Tripathi and Inani (2016) examined the long and short-term relationship between internet use and economic growth in 42 Sub-Saharan African countries for the period 1998-2014. A cointegrated relationship was found between the variables. The analysis findings show that internet use significantly and positively affects economic growth in the long term, and the short-term parameter is negative. Ghosh (2017) concluded that broadband policies had a limited effect on economic growth in his study analyzing 15 MENA countries for the period 2001-2014. Pradhan et al. (2019) analyzed the

relationship between venture capital investment, ICT infrastructure and economic growth for 25 European countries with data for the period 1989-2016. The panel cointegration test results used in the study showed the existence of a long-term relationship between the variables. As a result of the study, it was seen that economic growth affected internet use in the long term. In addition, it was observed that there were strong connections between the variables in the short term.

Haftu (2019) used the two-stage panel GMM method in the study investigating the effects of mobile phones and internet on per capita income in Sub-Saharan Africa in 40 countries in the period 2006-2015. According to the analysis results, mobile phone use positively affects economic growth, while no effect was found in internet use. David (2019) investigated the long-run causality relationship between economic growth, development, and telecommunications for 46 African countries in the period 2000-2015. Causality tests reveal that there is a feedback causality between telecommunications infrastructures, economic growth, and development. Myovella et al. (2020) examined the contribution of digitalization to economic growth by comparing 41 Sub-Saharan African and 33 Organisation for Economic Co-operation and Development economies with the GMM method. It was concluded that digitalization positively affects economic growth. In another study for African countries, Solomon and Van Klyton (2020) investigated the effect of digital technology use on economic growth in a panel of 39 African countries. According to the GMM estimator results, individual digital technology use has a positive effect on economic growth. Habibi and Zabardast (2020) found that information and communication technologies were positively related to economic growth using OLS, fixed effect and GMM methods for the period 2000-2017 in 10 Middle East and 24 OECD countries. Bakari et al. (2022) examined the effects of digitalization and trade openness on the economic growth of the 10 richest Asian countries with the gravity model and GMM method for the period 1990-2020. The results showed that digitalization has a significant positive effect on economic growth. Ozturk and Ullah (2022) examined the period 2007-2019 for 42 OBRI countries with OLS, 2SLS and GMM approaches in their study. As a result of the analysis, it was determined that the increase in the scope of digital transformation in the financial sector increased economic growth. Ngameni et al. (2022) examined China and 30 African countries in their study for the period 2000-2016. They show that the digital divide between China and Africa has a positive and significant effect on the economic growth gap.

In a study covering 27 member countries of the European Union, Evangelista and colleagues (2014) revealed that digitalization has a positive and encouraging effect on economic

growth and employment. In contrast, in a study conducted by Vyshnevskyi et al. (2021) on the EU-28 countries, it was concluded that the level of digitalization does not have a direct determining effect on economic growth. However, it was determined that there is a bidirectional causal relationship between internet use and economic growth. On the other hand, Akyol et al. (2023) found that digitalization indicators have a statistically significant and positive effect on economic growth in their panel data analysis conducted with data from the period 2000-2020 for the EU-27 countries. The Driscoll-Kraay standard error estimation method was used in this analysis.

In studies analyzing countries by separating them according to their development; Erdil (2009) found that information and communication technologies had a positive effect on economic growth in 131 underdeveloped and developing countries in the period 1995-2006. Turedi (2013) used fixed and random effect panel data analysis in his study and practically examined the effect of information and communication technologies on economic growth for 30 developing countries and 23 developed countries for the period 1995-2008. The results showed the positive effect of information and communication technologies on economic growth in both developed and developing countries. Saidi and Mongi (2018) examined the period 1990-2015 for 28 high-income countries in their study. According to the causality results in the study; there is a bidirectional causality relationship between internet users and economic growth in the short term, there is a unidirectional causality relationship from internet users to economic growth in the long term, and a unidirectional causality relationship from mobile phone usage to economic growth in the long term was determined. Hosan et al. (2022) showed in the study that digitalization promoted sustainable economic growth in 35 developing countries between 1995-2018.

If we give an example of single-country analyses in the selected literature on digitalization and economic growth; Salahuddin et al. (2015) estimated the short- and long-term effects of social capital and internet use on economic growth for Australia using data for the period 1985-2013. Hansen-Gregory and ARDL bounds tests confirm the cointegration relationship between the variables. ARDL estimates show that there is a significant and long-term positive relationship between economic growth and internet use. There is a finding of mutual causality between internet use and economic growth. Ozkan and Celik (2018) examined the effect of information and communication technologies on economic growth for Türkiye using the period 1998-2015. According to the results of the causality analysis used in the study, mobile phone use is the cause of GDP, there is a bidirectional causality relationship between

the internet and GDP, and there is a bidirectional relationship between landline telephone and GDP. Aleksandrova et al. (2022) examined the impact of digitalization on economic growth by grouping it according to measurement units, and emphasized that the positive impact of digitalization on economic growth in Russia can only be achieved if the economic environment is ready to accept this transformation. Ahmad et al. (2021) found in their study that the expansion of China's digital financial inclusion had a positive contribution to economic growth for the period 2011-2018. In another study on China, Ward and Zheng (2016) found that telecommunications made a significant contribution to economic growth in the period 1991-2010. In addition, the findings showed that mobile service contributed more to economic growth than fixed service.

As a result, there are no definitive results regarding the impact of digitalization on economic growth due to different countries and different econometric methods.

3. Dataset and Methodology

3.1. *Dataset*

This study examined the impact of digitalization on economic growth in the E7 countries (Brazil, China, Indonesia, India, Mexico, Russia and Türkiye) during the period 2003-2021. In the study, GDP per capita (current US$) was taken as the economic growth variable, exports of information and communication technology products, individuals using the internet (% of the population) and the number of mobile phone subscribers were taken as the digitalization variable. Variables other than the number of individuals using the Internet were included in the study by taking their natural logarithms and analyses were performed using the Stata package program.

Table 1.
Definition of Variables

Variable	Definition	Symbol	Resource
Economic Growth	GDP per capita (current US$)	LNGDP	World Bank
ICT Service Exports	ICT service exports (BoP, current US$)	LNEXP	World Bank
Individuals Using the Internet	Individuals using the Internet (% of population)	INT	World Bank
Mobile Cellular Subscriptions	Mobile cellular subscriptions	LNMOB	World Bank

In the study, panel data methods were used to investigate the long-term effect of independent variables on economic growth in the period 2003-2021, and the equation showing the long-term relationship can be expressed as follows:

$$LNGDP_{it}=\beta_0 + \beta_1 LNEXP_{it} + \beta_2 INT_{it} + \beta_3 LNMOB_{it} + u_{it} \quad (1)$$

In Equation 1, β_0 is the fixed value, β_1, β_2 and β_3 are the slope parameters, i is the unit size of the panel, t is the time dimension of the panel and u is the error term. In the study, the number of observations, mean, standard deviation, minimum and maximum values including descriptive statistical information on variables in E7 Countries (Brazil, China, Indonesia, India, Mexico, Russia and Türkiye) in the period 2003-2021 are presented in Table 2. According to descriptive statistics, it is seen that the data set consists of 133 observations.

Table 2.
Descriptive Statistics of E7 Countries

Variables	Observation	Mean	Std. Dev	Minimum	Maximum
LNGDP	133	8.5765	.8438	6.2986	9.6766
LNEXP	133	21.7458	1.6563	19.2271	25.5067
INT	133	37.3201	24.6486	1.6864	88.2138
LNMOB	133	19.1098	1.0977	16.7330	21.2807

3.2. Methodology

In this section of the study, basic information about the econometric methods used in the study will be presented.

3.2.1. Cross Section Dependency

The panel cointegration test developed by Gengenbach, Urbain, and Westerlund (2016) is among the second-generation methods that consider cross-sectional dependence. Therefore, it is necessary to test for inter-unit dependence before proceeding with the analysis. If such dependence is detected, first-generation tests such as those by Pedroni (1999) and Kao (1999) lose their validity; instead, it would be more appropriate to use second-generation tests such as those by Westerlund (2007) and Gengenbach, Urbain, and Westerlund (2016).

The existence of cross-sectional dependence is evaluated with Breusch Pagan (1980) CD_{LM1} test when the time dimension is larger than the cross-sectional dimension (T>N); with Pesaran (2004) CD_{LM2} test when the time dimension is equal to the cross-sectional dimension (T=N); and with Pesaran (2004) CD_{LM} test when the time dimension is smaller than the cross-sectional dimension (T<N). In the Berusch Pagan (1980) CD_{LM1} test, the hypotheses are expressed as follows:

H_0 = There is no cross-sectional dependence;

H_1 = There is cross-sectional dependence.

$$CDLM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^{2} \quad (2)$$

In this equation, $\hat{\rho_{ij}}^2$ represents the correlation coefficient between the coefficients of the i. and j. units. The null hypothesis of the test is "there is no relationship between the cross-sections". If the null hypothesis is rejected, it is concluded that there is a cross-section dependence and second generation unit root tests are preferred (Bucak and Saygılı, 2022: 356).

3.2.2. CADF Unit Root Test

The CADF test was introduced to the literature by Pesaran (2007). In the test, firstly the CADF test statistic is calculated for all units in the panel. In this test, instead of basing the unit root test on deviations from the estimated factors, the standard DF (or ADF) regressions are added to the cross-sectional averages of the lagged levels and the first differences of the individual series. The CADF (Cross-sectionally Augmented ADF) model is expressed as follows:

$$\Delta y_{it} = \alpha_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_{i,t} + e_{it} \quad (3)$$

The hypotheses tested for the CADF unit root test are as follows (Guloglu and Ivrendi, 2008: 2):

H_0: $b_i = 0$, the series is not stationary (For all variables)

H_1: $b_i < 0$, series is stationary (For at least one variable)

3.2.3. Testing Homogeneity of Variables

The delta test developed by Pesaran and Yamagata (2008) can be used to determine whether the slope coefficients are homogeneous or heterogeneous. We can show the delta test statistics as follows:

$$\tilde{\Delta} = \sqrt{N}\left(\frac{N^{-1} S - k}{\sqrt{2k}}\right) \quad (4)$$

$$\tilde{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1} S - E(Z_{it})}{\sqrt{var\,(Z_{\{it\}})}}\right) \quad (5)$$

3.2.4. Cointegration Test

In case of inter-unit correlation and heterogeneity, second generation panel cointegration tests are used. In this study, the second generation cointegration test introduced to the literature by Gengenbach et al. (2016) was used. The basic hypothesis of the Gengenbach et al. (2016) cointegration test is as follows:

H_0: p>0.01 (There is no cointegrated relationship)

H_1: p<=0.01 (There is a cointegrated relationship)

The stages of the cointegration test by Gengenbach et al. (2016) are as follows:

$$\Delta yi,t = \delta'_{y,x,}dt + a_{yi}\, y_{i,t-1} + y_i\, w_{i,t-1} + B_{y,yi}(L)\Delta y_{i,t-1} + A_{y,x,xi}(L)\Delta X_{i,t} + A_{y,F,Xi}(L)\Delta F_t + \eta'_{y,xi}\, fit + \varepsilon_{y,xi,t} \quad (6)$$

For each unit;

$$\Delta y_i = d\, \delta_{y,xi} + a_{yi}\, y_{i,-1} + w_{i,} - 1\, \hat{\gamma}_i + v_i\, \pi_i = a_{yi}\, y_{i,-1} + g_i^d \lambda_i + \varepsilon_{y,xi} \quad (7)$$

3.2.5. Estimating Long-Term Cointegration Coefficients

As a result of detecting the existence of cointegration, Pedroni (2001) Average Group Dynamic Least Squares (DOLSMG) estimator was used, which allows the calculation of long-term coefficients of the series and takes into account the correlation and heterogeneity between units.

It is seen that the DOLSMG estimator of Pedroni (2001) is based on the following model (Tatoğlu, 2017: 223-237);

$$Y_{it} = \mu_i + \beta_i X_{it} + u_{it} \quad i=1,2,\dots\dots\dots,N, \qquad t=1,2,\dots\dots\dots,N \quad (8)$$

3.2.6. Panel Causality Test

This test developed by Dumitrescu and Hurlin (2012) takes into account the cross-sectional dependence among the countries forming the panel. It is insensitive to the size difference between the time dimension and the cross-sectional dimension and provides effective results when the time dimension is larger or smaller than the cross-sectional dimension:

$$x_{i,t} = \alpha_{\mathrm{i}} + \sum_{k=1}^{k} \gamma_i^{(k)}\, x_{i,t-k} + \sum_{k=1}^{k} \beta_i^{(k)}\, y_{i,t-k} + e_{i,t} \quad (9)$$

$$y_{i,t} = \alpha_i + \sum_{k=1}^{k} \gamma_i^{(k)} \; y_{i,t-k} + \sum_{k=1}^{k} \beta_i^{(k)} \; x_{i,t-k} + e_{i,t} \tag{10}$$

Considering the first equation of the panel VAR model in Equation 8, when the lag length (k) is the same for each unit of the panel and the panel is balanced, the autoregressive parameter γi (k) and the slopes βi (k) differ according to the units. The basic hypothesis is established as "all βi are equal to zero" and explains that there is no causality from X to Y for the entire panel (Yerdelen Tatoğlu, 2020: 154-155).

The test statistic used to test the main hypothesis is the simple average of individual Wald statistics. $W_{i,T}$ in equation (9) indicates the Wald test statistic used to test n Granger causality for the i. country. Since individual Wald statistics do not converge to the same chi-square distribution for small values of T, Dumitrescu and Hurlin (2012) suggested using the estimated standardized test statistic for $W_{N,T}^{Hnc}$ using the estimated values of the mean and variance of this unknown distribution (Bozoklu and Yılancı, 2013: 161-187):

$$\tilde{Z}_{N,T}^{HNC} = \frac{\sqrt{N} \; \left[W_{N,T}^{Hnc} - \sum_{i=1}^{N} E\left(\tilde{W}_{i,T}\right)\right]}{\sqrt{\sum_{i=1}^{N} Var(\tilde{W}_{i,T})}} \tag{11}$$

4. Results and Discussion

The Breusch-Pagan LM test was applied to determine the correlation between units. In order to apply this test, the T>N condition must be met. Since T=19, N=7, this condition is met. Therefore, to test the existence of cross-sectional dependence, the Breusch-Pagan LM test results were examined. The results obtained through the Breusch-Pagan LM test are shown in Table 3. Since the probability values in Table 3 are less than 0.05, cross-sectional dependence was found in the model.

Table 3.
Cross Section Dependency Test Results

CD Test	**Test Statistic**	**Prob.**
LM_1 (Breusch Pagan 1980)	62.59	0.000
LM_2 (Pesaran 2004)	11.95	0.000
LM Bias Adj.	5.942	0.000

As a result of incorrectly ignoring the slope heterogeneity, biased results may be obtained in the study (Pesaran and Smith, 1995). For this reason, it was determined whether the slope

coefficients were homogeneous or heterogeneous in the study. According to the homogeneity test results of the model presented in Table 4; H_0 hypothesis was rejected ($p=0.00<0.05$) and it is seen that the slope coefficients are heterogeneous. In other words, the slope parameters vary between the horizontal sections.

Table 4.
Homogeneity Test Results of the Model

	Test Statistic	Prob.
Δ	9.923	0.000
Δadj	11.560	0.000

As a result of the cross-sectional dependency and homogeneity test findings, second generation methods that assume heterogeneity and take cross-sectional dependency into account will be taken into consideration in the following stages. When the unit root test results presented in Table 5 are examined, it is seen that the series are not stationary at the level, but when their first differences are taken, they become stationary, that is, they are I(1).

Table 5.
CADF Unit Root Test Results

Level		Constant		Constant and trend
Variables	Z[t-bar]	Prob.	Z[t-bar]	Prob.
LNGDP	0.970	0.834	-0.009	0.496
LNEXP	-1.223	0.111	0.222	0.987
INT	2.033	0.979	2.859	0.998
LNMOB	-1.091	0.138	-1.153	0.124
First Difference		Constant		Constant and trend
Variables	Z[t-bar]	Prob.	Z[t-bar]	Prob.
LNGDP	-1.753	0.040*	-0.987	0.162
LNEXP	-1.382	0.084**	-0.434	0.332
INT	-1.586	0.056**	-2.205	0.014*
LNMOB	-3.157	0.001*	-2.425	0.008*

Note: *, ** denote significance at 5% and 10% levels, respectively.

In this study, Genganbach et. al (2016) cointegration tests were applied to examine the long-term relationship between the series. According to the panel cointegration test results, when the significance of y(t-1) is examined, it is seen that the probability value is <0.01.

In the light of the findings obtained from Table 6, since $p<0.01$, the H_0 hypothesis was rejected and the alternative hypothesis, H_1, was accepted. In other words, it was decided that there was cointegration between the series, and coefficient estimates were made for the cointegrated series and the results are presented in Table 7.

Table 6.
GUW Cointegration Test Results

	Coefficient	T-bar	Prob.	Result
LNGDP=f (LNEXP, INT, LNMOB)	-1.424	-4.222	<=0.01	Cointegrated

Since cointegration relationship was determined between variables and suitable for models with heterogeneous slopes, DOLSMG estimator was used. According to DOLSMG long-term coefficient estimation results expressed in Table 7, there is a positive and significant relationship between information and communication technology products exports, individuals using internet and mobile mobile phone subscribers representing digitalization variable for the entire panel and economic growth. This situation shows that increasing digitalization supports economic growth in E7 countries. When the magnitude and direction of the effect of explanatory variables on economic growth is evaluated; in the long term, the number of mobile mobile phone subscribers has been the most effective factor in economic growth among information and communication technology products exports, individuals using internet and mobile mobile phone subscribers representing digitalization variable. According to DOLSMG estimator, 1% increase in the number of mobile mobile phone subscribers in the panel in general causes approximately 0.77% increase in economic growth.

According to the coefficient estimation results, the information and communication technologies export variable has an increasing effect on economic growth in all E7 countries. Russia is the E7 country where a one-unit increase in information and communication technologies export has the greatest effect. When examined on a country basis; the countries where a significant result is reached between individuals using the internet and economic growth are Brazil, Indonesia, India, Mexico and Türkiye. The effect of individuals using the internet on economic growth is positive in Brazil, Indonesia and Mexico; and negative in India and Türkiye. However, the coefficient of this variable is not found significant in China and Russia. The E7 country where a one-unit increase in the number of individuals using the internet has the greatest effect is Brazil. The countries where a significant result is reached between the mobile phone subscription variable and economic growth are Brazil, Indonesia, India, Mexico and Russia. While the increase in mobile phone subscriptions in Brazil, Indonesia, Mexico and Russia positively affects the economic growth of these countries, the increase in mobile phone subscriptions in India negatively affects economic growth. The E7 country where a one-unit increase in the number of mobile phone subscribers has the greatest effect is Brazil, and the E7 country where it has the least effect is Mexico.

Table 7.

DOLSMG Long-Term Coefficient Estimation Results

Countries	**LNEXP**	**INT**	**LNMOB**
Group Mean	.7072*	.01353*	.7727*
Brazil	.4985*	.2058*	3.456*
Çhina	1.453*	-.0358	.2703
Indonesia	.4024*	.0188*	1.246*
India	.1757*	-.0508*	-.5481*
Mexico	.6102*	.0090*	.1661*
Russian Federation	1.741*	.0029	.8166*
Türkiye	.0686*	-.0552*	.0021

Note: *denotes significance at 5% level.

Table 8 shows the Dumitrescu and Hurlin Panel causality test results. The lag length in the test was selected according to AIC. It was observed that there is a bidirectional causality relationship between economic growth and information and communication technology product exports in E7 countries. In addition, the findings reveal that there is a unidirectional causality from individuals using the internet to economic growth and from economic growth to mobile phone subscriptions.

Table 8.

Dumitrescu-Hurlin Panel Causality Test Results

	Z-Bar Test Statistic	Optimal Lag Length (AIC)	Prob.	Result
	6.5599	4	0.0000*	
LNGDP-LNEXP	7.4111	4	0.0000*	LNGDP ⟷ LNEXP
	-0.4753	1	0.6346	
LNGDP-INT	1.9282	4	0.0538**	INT → LNGDP
	1.6378	1	0.1015	
LNGDP-LNMOB	2.4832	3	0.0130*	LNMOB → LNGDP

Note: *, ** denote significance at 5% and 10% levels, respectively.

5. Conclusion

In this study, the effect of digitalization on economic growth in E7 countries was investigated in an applied manner, and it was found that the variables representing digitalization for the entire panel, information and communication technology exports, the number of individuals using the internet and mobile phone subscriptions, positively affected economic growth. Panel causality analyses revealed that there is a bidirectional causality relationship between economic growth and ICT product exports, while a unidirectional causality

relationship was found between the number of internet users and economic growth, and between economic growth and mobile phone subscriptions. These findings show that digitalization has a function that supports economic growth both directly and indirectly. In this respect, the findings of the study are similar to the studies of Chio and Yi (2009), Artan et al. 2014, Myovella et al. (2020), Salahuddin et al. (2015).

Digital infrastructure investments should be increased in E7 countries. In particular, incentives should be provided for the dissemination of internet access and mobile technologies. It should be emphasized that more financial resources should be allocated to research and development (R&D) and innovation activities in order to improve the export capacity of information and communication technologies (ICT) products. Aligning education policies aimed at increasing digital literacy with digital skills should be seen as a critical path in this process. In addition, future research can examine the impact of digitalization on economic growth at a sectoral level. Studies based on production function can be developed.

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