

Impact of Economic Integration and Information and Communication Technology on Economic Growth for European Union: Dynamic Panel GMM Approach

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Abstract

European Union is the strongest economic union globally and has observed rapid economic growth in the last few decades. This study investigates whether economic integration and information and communication technology (ICT) promotes economic growth in the EU. Additionally, the study examines the role of ICT for economic integration and growth relationship concerning ICT readiness and usage. The study undertook panel data from 2002 to 2019 and employed the Generalized Method of Moments approach to estimate results. The results revealed that economic integration and ICT enhance economic growth. Moreover, enhanced ICT stimulates the impact of economic integration on economic growth. The results also confirmed a more substantial effect of ICT usage on economic growth than ICT readiness.

Keywords: Economic integration, Information and communication technology, Economic growth, EU, GMM

1. Introduction

Economic growth enhancement is the principal objective of every economy that has been immensely contributed by economic integration. Theoretically, economic union or integration enhances productivity, capital accumulation and economic growth (Ehigiamusoe and Hooi, 2019). European Union (EU) is an economic, monetary and political union of 27 European countries establishment in 1957. Since its establishment, the next decade of the 1960s was quite significant with an economic growth perspective as custom duties on trade were eliminated for member countries. In 1986, the member countries signed the Single European Act, a vast program of six years. The primary purpose of this treaty was to create a “Single Market” by resolving issues related to the free flow of trade at EU borders. In 1993 EU completed single market and achieved “four freedoms”. The “four freedoms” agenda includes free movement of money, goods, people and services across the EU. In the 1990s EU also signed two treaties, the Maastricht treaty and the treaty of Amsterdam. Maastricht treaty was signed in 1993, which renamed European Economic Community (EEC) to European Community to express the integration of region beyond economic matters. In 1999 Amsterdam treaty was signed through which some certain powers of the national government were transferred to the European parliament. In 2007, the Treaty of Lisbon was signed by the EU, which established centralized foreign policy, leadership and proper process for the country who wishfully applied to exit from the EU. Moreover, the EU has established many Free Trade Agreements (FTAs) with various countries worldwide including Georgia, Mexico, Moldova, South Korea, Colombia, Peru and Ukraine. Additionally, the EU has enhanced its economic integration with other countries by signing some additional trade agreements comprising of Association Agreements (AA), Custom Unions (CU), Economic Partnership Agreement (EPA) and European Economic Area (EEA). EU is the most potent economic union and the largest trading bloc in the world. EU’s trade is 20% of global exports and imports, excluding intra EU trading activities (Chandan & Nalin, 2018). Despite all these economic integration enhancements, EU member countries observed slow economic growth in the last couple of decades. The average annual GDP per capita growth rate of the EU from 1998 to 2007 was 2.29 % but the average from 2008 to 2017 was significantly dropped down to 0.57% (WDI, 2019).

Information and Communications Technology (ICT) is inevitable for economic growth (Kuznets 1978). In the modern era of globalization, ICT has immensely reshaped the trade landscape leading to enhanced economic growth. However, this role is not a smooth process (Field 2006). History reveals that the transmission, innovation, or the collapse of the latest technologies accelerates or decelerates the economic growth abruptly. In particular, Information and Communication Technologies (ICT) transforms the firm’s production processes, which ultimately transmute the country’s overall production process and economic growth (Jalava and Pohjola, 2008). Therefore, this nexus needs empirical investigation.

Since 2007, ICT observed the emergence of novel innovations had increased the interest of

numerous policymakers and researchers at EU. In 2010 European Union launched Digital Agenda (DA) across Europe to contribute significantly towards the economic growth of the EU and extend the benefits of the digital era to every part of society. The EU's digital agenda focuses on developing infrastructure for enhanced access towards fast internet connections, innovation in ICR, knowledge development, and implementing intelligent use of ICT across all parts of society, i.e., health, energy, etc. The DA of EU has inspired local authorities, regions and national governments to develop digital agendas at their respective political levels to ensure priorities on policy settings and taking ICT initiatives (European Commission 2015). However, in the EU, various countries are at different levels of digital adoption.

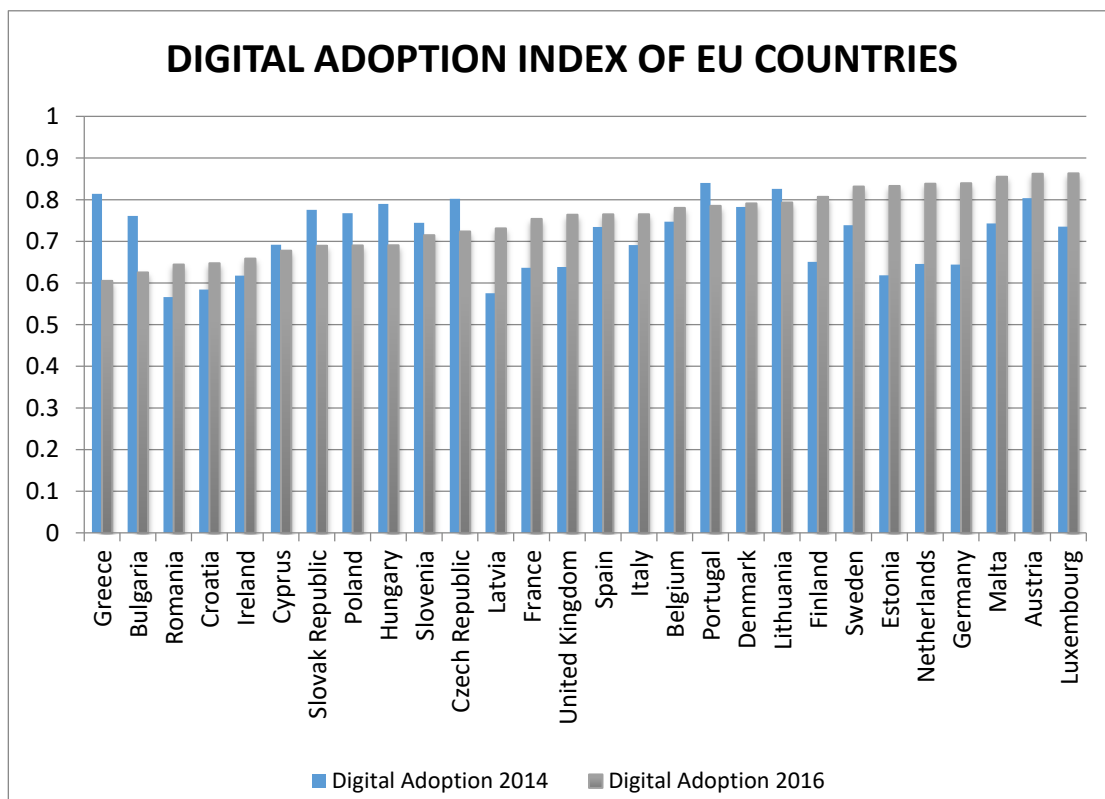


Figure 1. Digital Adoption Index of EU Countries

Source: World Development Indicators (2019)

Figure 1 shows Digital Adoption for EU countries on a scale of 0-1. EU countries are enhancing digital technology adoption as Figure 1 clearly illustrates that overall digital adoption increased in 2016 for most countries compared to 2014. It is also notable different EU countries have a different level of digital adoption, indicating a digital divide in the EU that can cause curb economic growth. Wyatt et al. (2005) defined digital as the overarching conception to capture unequal access to ICT at global and local levels. So, the phenomenon digital divide is based on access to ICT where access of ICT is grounded on ICT readiness. In the nutshell, the existence of the digital divide creates significance regarding the role of ICT for economic integration and growth nexus specifically with respect to ICT usage and readiness.

2. Literature Review

The theoretical basis of this study is established on endogenous growth model and new trade theory. Various past studies have used endogenous growth models and new trade theory as theoretical framework to investigate the economic integration and growth nexus (Tumwebaze & Ijjo, 2015; Bong & Premaratne, 2018). Bong and Premaratne (2018) conducted a panel data analysis on ASEAN region to investigate the impact of economic integration on growth by considering endogenous growth model. The authors took data of 43 years ranging from 1970 to 2013 and reported a significant positive impact of regional economic integration on economic growth. Similarly, Tumwebaze and Ijjo (2015) considered the new trade theory to investigate the impact of economic integration on growth. The authors concluded that economic integration significantly contributed to GDP growth in COMESA.

Balassa (1961) carried out the first key systematic descriptive study based on economic integration. Since then, various studies have shown different results for economic integration and growth relationship. Landau (1995) conducted a study on 17 OECD countries from 1950 to 1990 and reported that economic growth observed no impacts from integration. Another study conducted by Brada and Mendez (1988) used Pooled data set of EU countries revealed that investment affects growth in the region. However, OLS estimation suggested that integration has no impact on economic growth. Similarly, Badinger (2005) built a different construct that changed from EU membership to account for economic integration. He constructed a dynamic process to measure EU integration that considers complex global tendencies and includes the impact of various speeds of integration. The researcher used panel data for fifteen EU member states from 1950 to 2000. However, he claimed that economic integration had no permanent effects on economic growth but confirmed the level effects of EU's integration. The author concluded that the GDP of the EU would be 20 percent less in the absence of EU economic integration.

On the contrary, many studies revealed a positive and significant impact of EU integration on economic growth. Italianer (1994) organized a study to investigate the impacts of regional integration on economic growth by selecting six EU countries for 1961-1992. He used integration measuring variables based on trade flows for the estimation of results. The author reported significant growth effects of general levels of openness and regional economic integration. Henrekson et al. (1997) confirmed that European integration has a significant and permanent impact ranging from 0.60 to 1.30 percent per annum on the growth of the EU that was rejected by Vanhoudt (1999). Moreover, Fetahi-Vehapi et al. (2015) also conducted a study on ten southeast European countries examining the impact of trade openness and growth. They reported that trade openness affects economic growth positively in Europe. Although the impact of European integration on economic growth remains inconclusive due to methodological difficulties but significant heterogeneity is also observed across countries Campos (2018), which is a severe concern for growth (Crespo et al., 2008).

Information and Communication Technology (ICT) has also contributed to economic growth (Dewan, 2000; Cardona, Kretschmer, & Strobel, 2013; Ishida, 2015). Gruber et al. (2014) conducted empirical analysis for 27 EU countries by using panel data from 2005-2011 and

reported that broadband adoption has a positive and significant effect on economic growth. On the other hand, many studies investigated the impact of ICT on economic growth for EU member countries that showed contradictory results (Kraemer & Dedrick, 2001; Jalava & Pohjola, 2007; Vijselaar & Albers, 2004; Timmer et al., 2007; Venturini, 2009). Moreover, many theoretical and empirical studies on economic integration and growth nexus also revealed mixed results (Harrison, 1996; Yanikkaya, 2003; Dowrick & Golley, 2004; Rassekh, 2007). So, the digital divide in the EU and contradictory outcomes of economic integration and growth nexus, it is essential to explore the impact of economic integration and ICT on economic growth and the role of ICT for economic integration and growth nexus.

3. Data and Methodology

The study undertakes a panel dataset of 27 EU countries ranging from the year 2002 to 2019. The annual data is obtained from various data sources, including World Bank, International Telecommunications Union (ITU) and Penn World Table (PWT) version 9.1. The observations are constructed as non-overlapping average of three years that provides six periods for 27 EU countries. The three-year average is constructed to mitigate business cycle fluctuations and capture the actual effect of economic integration on growth in long- and medium-term variations instead of short-term variations. More particularly, the non-overlapping average assists in drawing results to be less subjective to the permanent and temporary shocks. Ehigiamusoe and Lean (2019) also suggested that many previous studies on economic integration used non-overlapping average data.

New Trade Theory and Endogenous Growth Model serve as theoretical support for this study. New Trade Theory states that increase in trade or enhanced economic integration upsurges economic growth. Moreover, Endogenous Growth Model postulates that determinants of economic growth are explained inside the model. AK model is a form of endogenous growth model that is based on physical capital accumulation. The model uses a basic production function

$$Y = AK \quad (1)$$

Where, Y shows the level of production, A denotes technology and K shows capital accumulation. This study extends above mentioned AK model by adding economic integration as duly supported by New Trade Theory. The study also examines the impact of ICT on economic growth. Further, the study also adopts human capital, employment rate and inflation as control variables (Chimobi 2010; Paparas, Richter, & Paparas, 2015; Ahmed & Ahmad, 2016 and Murphy, & O'Reilly, 2019).

The analysis of the study consists of descriptive statistics, correlation analysis and Dynamic Panel regression Generalized Method of Moments (Hansen, 1982). Generalized Method of Moments (GMM) considers the instrumental variable approach to estimate the results. Since the best fit instrumental variable is usually unknown, the lagged dependent variable is used as an an instrumental variable to infer results. These instrumental variables of the dynamic GMM estimators follow moment conditions and are used for short panels where the

cross-sections are more than the time intervals (Arellano & Bond, 1991; Arellano & Bover, 1995; Blundell & Bond, 1998). GMM is also used to rule out the problems of serial correlation and endogeneity. Further, to check the veracity of the results, the post-analysis tests of Sargan and Arellano Bond are used to check the validity of the instruments and serial correlation, respectively. Considering the GMM model, Equation (1) can be rewritten as:

$$\ln EG_{it} = \beta_0 + \beta_1 \ln EG_{it-1} + \beta_2 \ln EI_{it} + \beta_3 \ln ICT_{it} + \beta_4 \ln HC_{it} + \beta_5 \ln EMP_{it} + \beta_6 \ln INF_{it} + \varepsilon_{it} \quad (2)$$

Where t shows time period for each i country. Further, in Equation 2 EG , EI , ICT , HC , EMP , INF and ε denotes Economic Growth, Economic, ICT, Human Capital, Employment Rate, Inflation Rate and disturbance term, respectively. Betas denote coefficients and \ln natural indicates logarithm in the equation for all variables to standardize the dataset. The scope of the study is not limited to the impact of economic integration and ICT on economic growth. Still, it will also explore the role of ICT for economic integration and growth relationship. So, Equation (2) can be rewritten as

$$\ln EG_{it} = \beta_0 + \beta_1 \ln EG_{it-1} + \beta_2 \ln EI_{it} + \beta_3 \ln ICT_{it} + \beta_4 \ln ICT_{it} * \ln EI_{it} + \beta_5 \ln HC_{it} + \beta_6 \ln EMP_{it} + \beta_7 \ln INF_{it} + \varepsilon_{it} \quad (3)$$

The study considers ICT concerning readiness and usage. Therefore, regression analysis will be based on four models as the models presented in Equation 2 and Equation 3 will be examined concerning ICT readiness and usage.

Table 1. Data and Measurements

Variables	Definition	Proxy	Reference	Data Source
Economic Growth (EG)	Hussin and Saidin (2012) mentioned that economic growth is the measure of aggregate proliferation in the economic sectors of a country	Gross Domestic Product Per Capita (GDP per capita is a better measure for economic growth as it considers the change in population.)	(Makki & Somwaru, 2004; Iyidoğan et al., 2017; Bong & Premaratne, 2018 and Latif et al., 2018).	World Bank
Economic Integration (EI)	Machlup (1977) defined economic integration as the process through which different economies form a larger economic region	Total Trade as a percentage of GDP	(Grubert & Mutti, 2000; Devereux, Griffith & Klemm, 2002; Loretz, 2007 and Bong & Premaratne, 2018)	World Bank
Information and Communication Technology (ICT)	Yusuf (2005) described ICT as the diversified application of computing, telecommunication, communication and satellite technology	ICT Usage: Internet users per hundred populations (IU)	(Roller & Waverman, 2001 and Raheem, Tiwari, & Balsalobre-lorente, 2019)	World Bank and International Telecommunications Union (ITU)
		ICT Readiness: Mobile Phone Subscription (MS)	(Kumar & Kumar, 2019 and Maiti & Awasthi, 2019)	
Human Capital (HC)	Human capital can be defined as "the knowledge and skills that make a person productive" or as the "personal stock of knowledge, know-how, and skills that enables a person to be productive and thus earn income" (McConnell, Brue, and Flynn, p. 509, 283).	Human capital index based on years of schooling and returns to education	(Ahmed & Ahmad, 2016 and Murphy, & O'Reilly, 2019)	Penn World Table (PWT) version 9.1
Employment Rate (EMP)	Employment rate can be defined as the percentage of the labor force which is employed Hossine Sharif, S. (2016).	No. of Persons Engaged per million	(Baksa & Kónya, 2019)	Penn World Table (PWT) version 9.1
Inflation (INF)	Reilly, Johnson, and Smith (1970) defined inflation as a rise in the general price level of a country.	Consumer Price Index	Bruno and Easterly (1995); Chimobi (2010); Ahmed and Mortaza (2005); Saeed (2007)	World Bank

*, ** Internet usage and mobile phone subscription have been considered as proxies for ICT usage and readiness respectively, due to data availability

4. Results and Discussion:

This section consists of descriptive statistics of the data, correlation and dynamic panel GMM regression analysis, and diagnostic tests.

Table 2. Descriptive Statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
lnEG	overall	4.5860	0.5794	3.6257	6.6434	N = 162
	between		0.5789	3.9669	6.4567	n = 27
	within		0.1046	4.1584	4.8907	T = 6
lnEI	overall	2.0321	0.2023	1.6740	2.5990	N = 162
	between		0.1990	1.7271	2.5243	n = 27
	within		0.0505	1.8987	2.1297	T = 6
lnIU	overall	1.7811	0.1783	1.0068	1.9901	N = 162
	between		0.1074	1.5349	1.9461	n = 27
	within		0.1436	1.2530	2.0872	T = 6
lnMS	overall	6.9030	0.5990	5.4638	8.0413	N = 162
	between		0.6012	5.6484	7.9611	n = 27
	within		0.0927	6.5133	7.0458	T = 6
lnEI * lnIU	overall	3.6308	0.5783	1.7667	5.1567	N = 162
	between		0.4596	2.8626	4.8312	n = 27
	within		0.3602	2.5215	4.3305	T = 6
lnEI * lnMS	overall	14.008	1.7085	10.176	18.6203	N = 162
	between		1.6624	10.913	17.8898	n = 27
	within		0.4909	12.6914	14.7728	T = 6
lnEMP	overall	6.5011	0.5838	5.1698	7.6532	N = 162
	between		0.5914	5.2411	7.6193	n = 27
	within		0.0436	6.1504	6.6462	T = 6
lnHC	overall	0.50074	0.0425	0.3494	0.5822	N = 162
	between		0.0406	0.3725	0.5613	n = 27
	within		0.0143	0.4614	0.5448	T = 6
lnINF	overall	2.2705	2.0033	-1.6270	16.5667	N = 162
	between		1.0641	1.3806	6.1922	n = 27
	within		1.7077	-4.2783	12.6450	T = 6

Source: The authors

Table 2 indicates the data's descriptive statistics, including mean, standard deviation, total number of observations, number of cross sections, number of years, and minimum and maximum values. The total number of observations, number of cross-sections and number of the year groups are 162, 27 and 6, respectively. To standardize all the variables, natural logarithm is taken for all the variables denoted by “ln”. Economic Growth values range between 3.63 to 6.64 with mean of 4.59 and standard deviation of 0.58 indicating different economic growth in the the EU (Putranti, 2016). Similarly, the value of Economic Integration ranges between 1.67 to 2.60, with a mean of 2.03 and a standard deviation of 0.20 showing mild heterogeneity. Similarly, Inflation and Employment Rate have a slightly high standard deviation of 2.00, 0.58 respectively. Moreover, Mobile Phone Subscription and its interaction with Economic Integration have a higher standard deviation of 0.59 and 1.70, respectively, indicating the digital divide in the EU (Negreiro, 2015).

Table 3. Correlation Analysis

	lnEG	lnEI	lnIU	lnMS	lnEI*lnIU	lnEI*lnMS	lnEMP	lnHC	lnINF
lnEG	1.0000	-	-	-	-	-	-	-	-
lnEI	0.6783	1.0000	-	-	-	-	-	-	-
lnIU	0.1995	0.3148	1.0000	-	-	-	-	-	-
lnMS	0.2152	-0.1644	0.1655	1.0000	-	-	-	-	-
lnEI*lnIU	0.1632	0.6216	0.6969	-0.0150	1.0000	-	-	-	-
lnEI*lnMS	0.2538	0.6849	0.3568	0.6010	0.6392	1.0000	-	-	-
lnEMP	0.0378	-0.6845	-0.0230	0.2190	-0.4413	-0.3968	1.0000	-	-
lnHC	0.2131	0.1457	0.4551	0.3037	0.3559	0.3212	-0.0420	1.0000	-
lnINF	-0.2212	-0.0817	-0.5253	-0.1726	-0.3594	-0.1854	-0.0465	-0.4423	1.0000

Source: The authors

Table 3 depicts correlation analysis where all the variables were put into the bivariate correlation analysis to note their co-movements and the multicollinearity issues were also analyzed by the correlations coefficients. Notably, economic integration has a strong association with economic growth, whereas variables of ICT and their respective interactions have a weak correlation with economic growth. On the other hand, all independent and control variables, including interaction terms, have an association of less than 0.70, indicating that data is not impeded with multicollinearity (Lind, Marchal & Wathen, 2012; Vatcheva, Lee, McCormick & Rahbar, 2016).

Table 4. Dynamic Panel GMM Regression Analysis

	(1)	(2)	(3)	(4)
	lnEG	lnEG	lnEG	lnEG
	b/t	b/t	b/t	b/t
L1.lnEG	0.41977***	0.29058***	0.24182***	0.55643***
	(7.1)	(2.8)	(2.8)	(14.0)
lnEI	0.36907***	3.82505***	0.22944**	0.38469*
	(3.4)	(2.7)	(2.5)	(1.8)
lnEMP	1.30485***	1.32176***	1.33134***	0.77859***
	(5.9)	(5.5)	(8.9)	(15.1)
lnHC	0.20200	0.46225	2.65138***	1.03709**
	(0.2)	(0.4)	(3.1)	(2.5)
lnINF	0.00037	-0.00078	0.00058	-0.00123**
	(0.4)	(-0.8)	(0.6)	(-2.5)
lnIU	0.16262**	-4.14710***	-	-
	(2.2)	(-2.8)		
lnEI * lnIU	-	2.15698***	-	-
		(2.9)		
lnMS	-	-	0.12029*	-0.25809***
			(1.8)	(-3.4)
lnEI * lnMS	-	-	-	0.07259**
				(2.1)
Observations	138	138	138	138
No. of Groups	27	27	27	27
No. of Instruments	18	18	19	21
AR1	0.056	0.049	0.049	0.146
AR 2	0.388	0.103	0.697	0.090
Hansen	0.097	0.807	0.569	0.110
Sargan	0.337	0.666	0.595	0.122

Source: The authors.

Notes: The t-statistics are in parentheses. *, ** and *** indicate statistically significant at 10%, 5% and 1% level, respectively.

The GMM results are computed by using xtabond2 command robust standard errors in STATA 16.

Table 4 shows Two-Step Difference GMM regression analysis and diagnostic tests, including the Arnello Bond test, Hansen and Sargan test. The regression analysis consists of four models where economic growth is the dependent variable and the first lag of economic growth, economic integration, human capital, employment rate and inflation are taken as regressors. Internet Users and Mobile Phone Subscribers are taken as regressors with ICT usage and readiness in model one and model three, respectively. Further, in models two and four, Internet Users and Mobile Phone Subscribers are used as regressors with economic integration interaction.

In all four models, the first lag of economic growth impacts positively on economic growth. The coefficients are 0.41977, 0.29058, 0.24182 and 0.55643 for models one, two, three and four, respectively. All coefficients are significant at 1% that confirms the dynamic impact of economic growth in all four models (Bong & Premaratne, 2018). Similarly, Economic Integration also impacts positively and significantly on economic growth in all four models. The results of economic integration and growth nexus are also consistent with previous

studies (Kien, 2009; Sharma & Chua 2000; Vogiatzoglou & Nguyen, 2016 and Bong & Premaratne, 2018). In the same way, the Employment rate has a positive and significant impact on economic growth as all the coefficients are significant at 1% in all four models (Ahmad & Ahmed, 2016). Further, the human capital has a positive and insignificant impact on economic growth in the first two models but the results are significant in the last two models (Barro, 1991; Hanushek & Kimko, 2000; Greenway et al., 2002; Ndambiri et al., 2012; Bong & Premaratne, 2018). On the other hand, the impact of inflation is insignificant on economic growth in all models except model four where inflation has negative and significant impact on economic growth (Barro, 1995; Bruno & Easterly, 1998; Vaona & Schiavo, 2007; Vaon, 2012).

The results reveal the positive and significant impact of ICT on economic growth (Dimelis & Papaioannou, 2010; Vu, 2011; Ahmed & Ridzuan. 2013 and Sassi & Goaid 2013), where the magnitude and significance of mobile phone subscribers are more minor than internet users. Model two and four show the moderating role of ICT for economic integration and growth nexus. The interaction terms of internet users and economic integration in model two and mobile phone subscribers and economic integration in model four show that increased internet users and mobile phone subscriptions strengthen economic integration and growth relationship. On the other hand, the magnitude of internet users is more significant than mobile phone subscriptions. Table 4 also shows diagnostic tests for GMM regression, including Hansen and Sargan over-identification of instruments and Arnello Bond Serial Correlation test. For all four models, the number of instruments is less than the number of cross-sections. Moreover, the instruments are not over identified as p values for Sargan and Hansen tests are more than 0.05. Further, there is no serial correlation as the p-value of AR 2 is more than 0.05 for all four models.

5. Conclusion

This study investigates the impact of economic integration on economic growth and explores the role of ICT for economic integration and growth relationship. Additionally, human capital, inflation and employment rate are taken as control variables for the study. The results revealed that economic integration and ICT both have a significant and positive impact on economic growth. The results revealed that economic integration and ICT both have a significant and positive impact on economic growth in EU, that is in line with the postulations of both endogenous growth model and new trade theory. Furthermore, the impact of ICT usage or internet users on economic growth is more potent than ICT readiness or mobile phone subscription. Moreover, the employment rate and human capital have a positive and significant impact on economic growth, whereas inflation's impact is negative on economic growth. Further, results also indicated that enhanced internet usage and mobile phone subscription would strengthen economic integration and growth nexus. More specifically, the role of internet users is more dexterous for economic integration and growth relationship. Conclusively, Economic integration could serve as an essential factor for economic growth in EU region. Public institutions should highly consider implementing policies that can enhance economic integration to promote economic growth in EU countries. More specifically, our empirical results suggest that ICT usage and readiness are also

imperative to improve economic growth in EU member countries. Further policymakers should focus more on enhancing the number of internet users or ICT usage in the EU while planning for the Digital Agenda of the EU as it plays a more significant and positive role in economic integration and growth nexus. However, the study has not discussed any level or precise thresholds for ICT specifically with respect to ICT readiness and usage. Therefore, further research could be considered to determine to what extent the impact of ICT is significant for economic integration and growth nexus in the EU region.

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