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Information and Communication Technologies and Economic Growth: Evidence from EU and Turkey

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More and more information technology is considered as an indispensable dimension of the process of economic growth. The main aim of this paper is to explore the impact of ICT on economic growth in the European Union (EU) countries and Turkey, covering the 1997-2014 periods. The study contributes to the empirical literature by providing some evidence obtained by a cross-country panel data analysis. The results show that ICT investment appears to be quite important for explaining economic growth in the EU countries and Turkey.

ICT which we use growth rate of fixed telephone, internet and mobile telephones subscriptions as proxy variables has a positive effect on economic growth. Through static and dynamic panel data analyses, we found that fixed telephone subscriptions and internet variables have a positive effect on economic growth, while we could not observe a statistically significant correlation with mobile telelephone. As expected, there is a positive relationship of economic growth with physical capital growth but negative association with population growth. The effects of trade growth variable are controversial.

Keywords: Information technology, economic growth, panel data

JEL Classification: O33, O40, C23.

1. Introduction

There is no doubt that while growth performances differentiate across countries in the world, the determinants of growth can also be dissimilar for all countries. The growth pattern of the countries may be attributed to a group of factors, namely economic infrastructure, population growth,

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unemployment rate, inflow of foreign capital, industrial growth, inflation, investment in physical and human capital and development of financial institutions. Information Technology (IT) or Information Communication Technologies (hereafter written as ICT) is today indispensable part of economic growth. ICT plays a significant role in promoting competitiveness in international economy as well as rising domestic productivity in all fields of the economy. In making progress in ICT area also means to increasing examples of technological inventions and innovations. Countries in general and developing countries in particular in a rapidly changing environment of international economy have to pay a great attention to greater access and use of information infrastructure in order to achieve a sustainable growth and competitive economy.

In recent years, a growing number of academicians in the field of economics have become interested in the relationship between ICT and economic growth. The focus of attention on the role of ICT in economic performance has not only been on the advanced industrialised countries but it has also been on the developing countries. For dealing with such a relationship, it is better to investigate that how far ICT investment contributes to economic growth.

Indeed, the main purpose of this article is to examine the impact of ICT on economic growth in the European Union (EU) countries and Turkey in the period of 1997-2014. The group of the countries chosen in the analysis of this paper, the EU (28) plus Turkey involves both advanced industrialised countries and developing countries in Europe[3] Turkey is now an accession country, which means the last phase in the way of the EU full membership. Thus, the period of 1997-2014 for Turkey is important, because it includes both the dates of Custom Union membership (1996 and onwards) and post-accession process.

The study contributes to the empirical literature by providing some evidence obtained by a cross-country panel data analysis. In doing so, the study investigates to measure the effects of population, trade, total investments and ICT in the EU and Turkey for the years 1997-2014. The results indicate that ICT investment appears to be quite important for explaining economic growth in the EU and Turkey.

[3] Malta is excluded for the lack of data.

The rest of this paper is divided into five sections. A brief of the literature on the relationship between IT/ICT and economic growth introduced in Section 2. Section 3 details the data employed and outlines the main features of the econometric model. Section 4 sets out and discusses the results of empirical analysis obtained in this study. The final section summarizes the findings and conclusions of the study.

2. Brief Literature Review

A number of economists have made significant contributions to the understanding of how IT/ICT investments affect economic growth. The answer of this question extends from Solow's growth theory to its successors. Solow's theory was based on two external factors, namely population (labour) growth and technology. When an increase is realised in these factors, economic growth will occur (Solow, 1956). Solow, in a study related to USA economy, reached to a conclusion that the economic growth in the period of 1909-1949 can be explained by technology rather than labour and capital which classical theory stressed much (Solow, 1988).

Mankiw et al. (1992) developed Solow's model by incorporating human accumulation as well as physical capital, and arrived at a conclusion that the model (the augmented Solow model) clarifies per capita income level variations across countries (Mankiw et al. 1992: 407-408). Romer (1994) also emphasized that Research and Development (R&D) expenditure is the main factor of economic growth in a model that involves total production function, knowledge accumulation and R&D expenditures. Yoo (2003) extended the augmented Solow model a step further by explicitly including the IT investment in an analysis of 56 countries, and suggested that the contribution of information technologies on economic growth is significant.

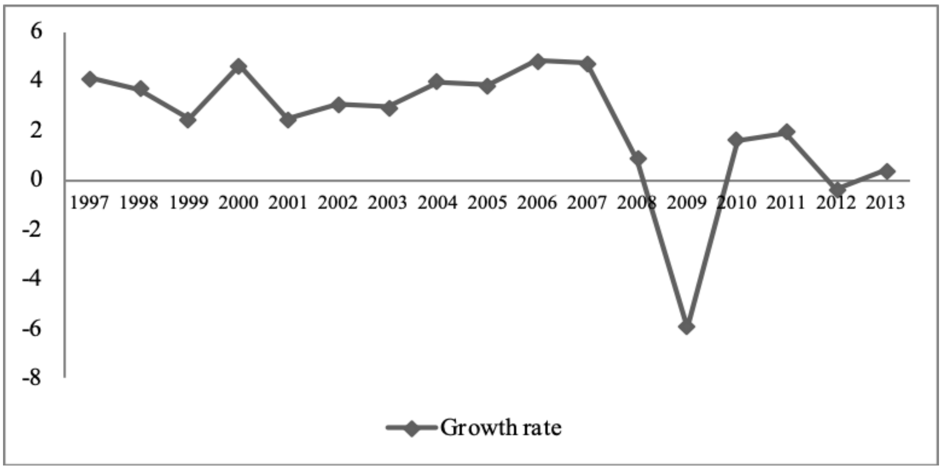
There are studies, however, like Pohjola (2000), who reach mix results. He examined the link between growth and IT using Solow model for 39 OECD countries in the period of 1980-1995 (Pohjola, 2000: 1-17). His main conclusion is that physical capital is the main factor both in developed and in developing countries. In this model there is no any significant relationship among human capital, knowledge capital and growth. But when he limited the scope of his study to 23 OECD countries, he reached a conclusion that IT investment has an powerful impact on growth (Pohjola, 2000). Dewan and Kraemer (2000) also reaches varied results for both country groups. They reached a conclusion that the effect of IT on economic growth is significant in developed countries. It is not however significant in the developing countries. They imply that developing countries have lacked sufficient stock of physical infrastructure and human capital which multiply the impact of investments in IT. Kraemer and Dedrick (2001) also reach similar results. However, there are studies which support that IT/ICT significantly contributes to developing countries. For instance, Vu (2011) used a panel data analysis and examined the linkage between ICT and economic growth in a sample of 102 countries for the years of 1996-2005. He found a robust causal link of ICT on growth (Vu, 2011: 372). Even Becchetti and Adriani (2005) showed that ICT factors also contribute to convergence as well as supporting growth rate of output per worker (Becchetti and Adriani, 2005: 451).

Empirical research on productivity improvements related to ICT also found evidence since the second part of 1990s. Many studies were shown in this context. Among these studies are, inter alia, those made by Brynjolfsson and Hitt (2000), Jorgenson and Stiroh (1999), Lehr and Lichtenberg (1999). Becchetti et al. (2003) examined the correlation of investment and firm efficiency with ICT and found evidence that ICT is relevant to improvements in productivity at firm level data when, in particular, breaking the data into software and telecommunications. They also note that more positive results are seen easily when new data are to inserted into a data structure and new methodologies were introduced (Becchetti et al. 2003: 143-144). Indeed, Papaioannou and Dimelis (2007) had similar research findings for 42 countries which are both developed and developing in 1993-2001 time span. They found a robust and positive impact of ICT on growth of both country groups, though the highest impact was observed in developed countries. Shahiduzzaman and Alam (2014) examined the multiple impact of IT in Australia for the period of nearly forty years. They made clear that capital of information technologies showed a notable effect on output, productivity of labour and technical progress in 1990s, in spite of the fact that there is a signs of deceleration of IT capital in output and labour productivity in recent times (Shahiduzzaman and Alam, 2014: 125).

3. Empirical analyse: The effect of ICT growth on GDP growth

Figure 1 shows the average growth rate of 29 European countries in the period of 1997-2014. By 2007, the average growth rate was above two percent and even more in the period of 2006-2007 reached nearly four percent. This trend of the growth rate of the EU countries was disrupted in 2008-2009 and could not be considered fully recovered afterwards.

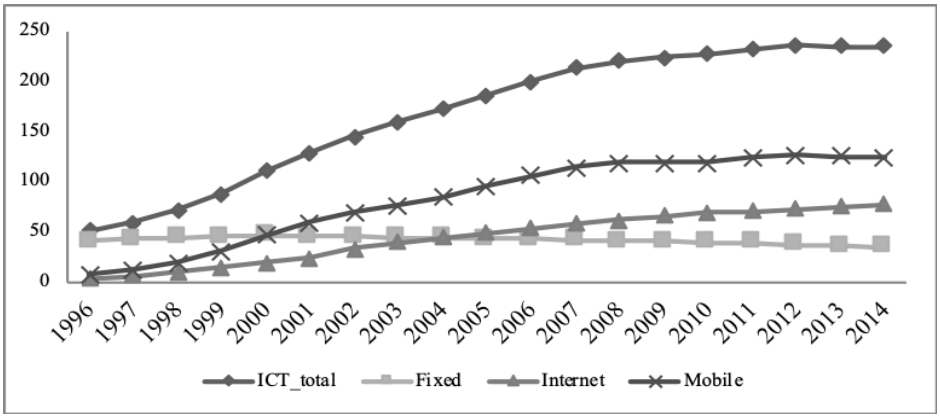
Figure 1: Average per capita GDP growth rates



Source: WDI Online DataBank (2018).

As shown in Figure 2, first salient point is that mobile telephone subscriptions (per 100 people) are in the steady increase while fixed line subscriptions (per 100 people) are steadily declining. A similar pattern of increase can also be seen in the use of the internet (per 100 people). Another important point is that all other variables except the fixed line whose growth rate falls moderately have started to decrease fast as a result of the crisis of 2008.

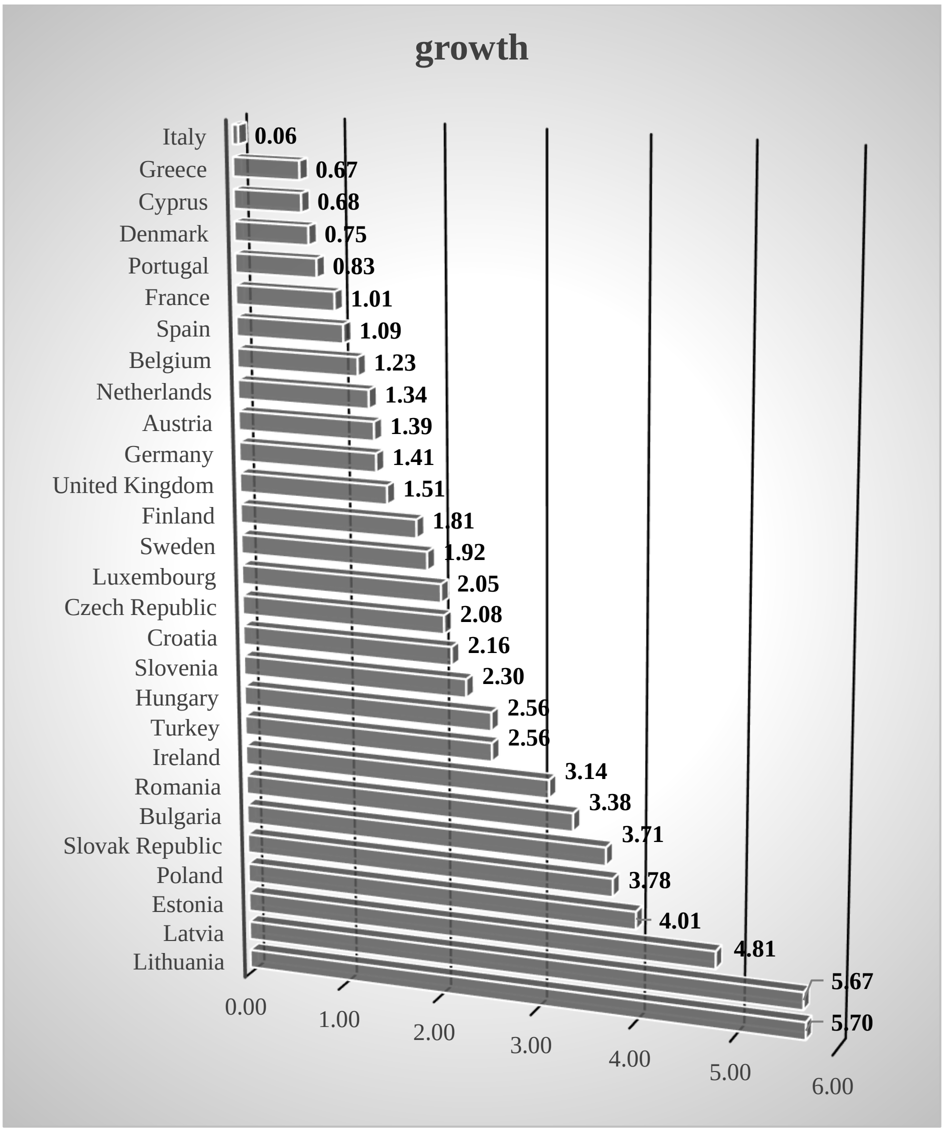
Figure 2: Average of ICT variables for all sample



Source: WDI Online DataBank (2018).

Figure 3 shows the average growth rates of 29 countries between 1997-2014 periods. All countries which take place in the figure differ in terms of per capita growth performance. It is observed that the countries apart from Ireland that shows higher performance are Middle and East European countries in general, and Baltic countries in particular. Turkey represents the average level while West European countries display relatively lower per capita growth by performance measure in Figure 3.

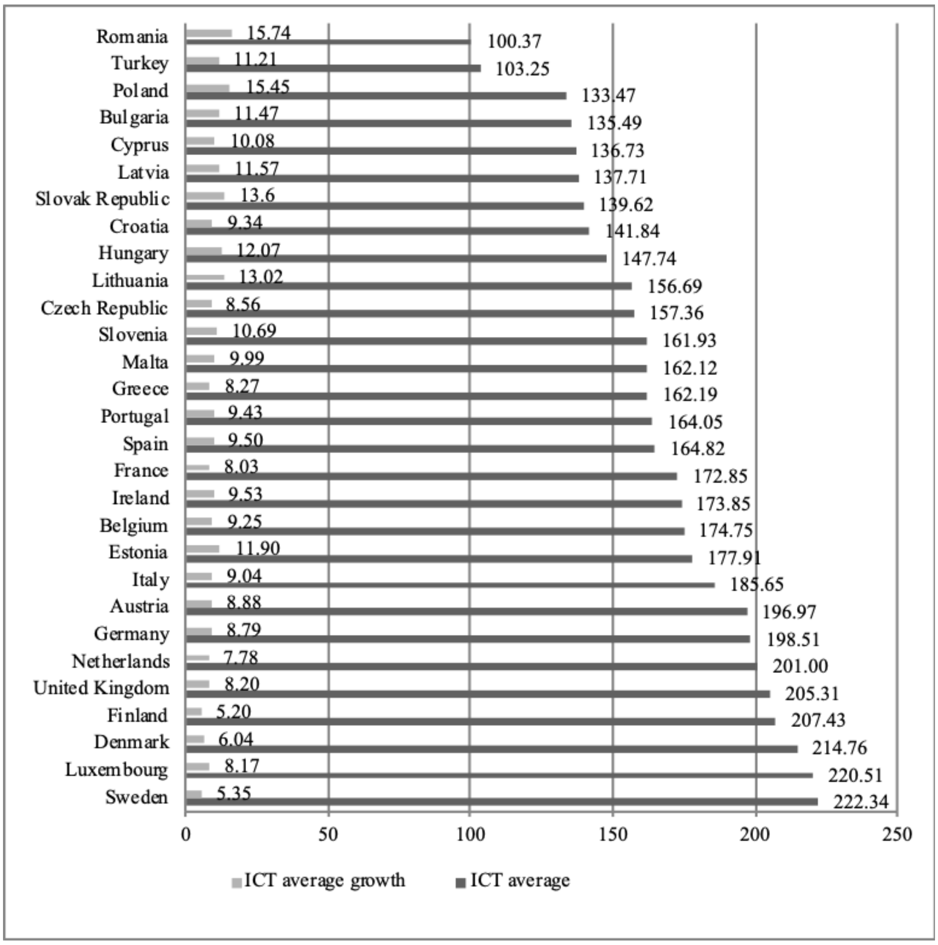
Figure 3: Average per capita GDP growth rates for countries (1997-2014)



Source: WDI Online DataBank (2018).

The variables of average ICT ratio and growth rate of ICT have been shown in Figure 4. While Romania with 100.37 has the lowest ICT stock (per 100 people) nearly same as Turkey with 103.25 for the period of 1997-2014, the highest ICT stock figure of 222.34 was observed in Sweden. The relationship between ICT growth and ICT stock is also clearly visible. Romania, which ranks first in terms of growth with 15.74, is the last country in terms of ICT stocks with 100.37. Poland is the second in terms of growth rate with 15.45 while it is the third country (133.47) with the lowest ICT capacity. The two countries that have disrupted this general tendency are Estonia and Cyprus. Estonia's relatively high ICT stock with 177.91 also has a high growth rate with 11.9 per 100 persons. In the case of Cyprus, both the ICT growth rate (10.08) and the stock (136.73) are low.

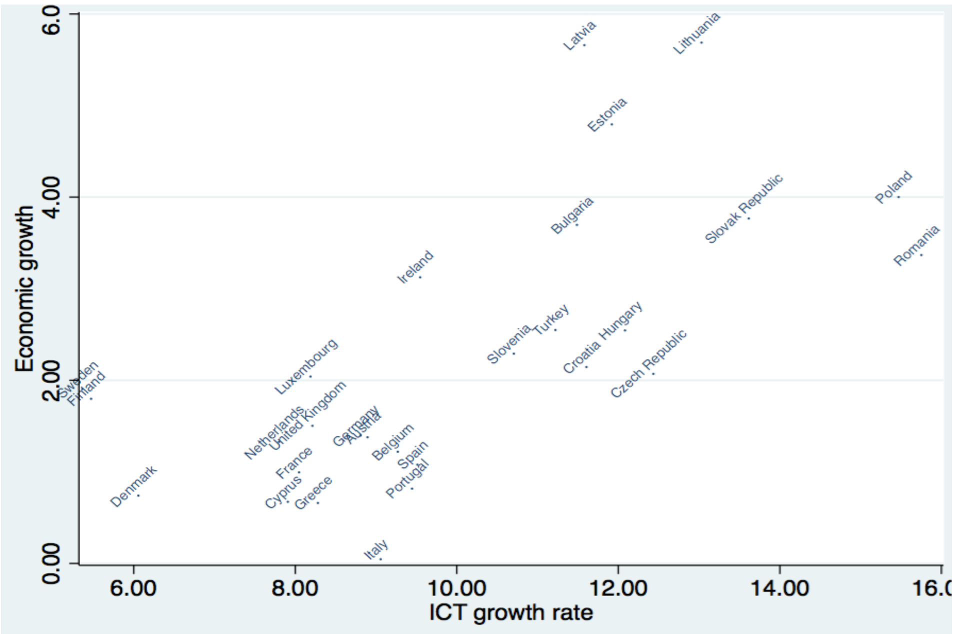
Figure 4: Average of ICT variables growth rate for all sample (1996-2014)



Source: WDI Online DataBank (2018).

Figure 5 examines the effect of ICT growth rate on GDP growth. There is a discernible relationship between ICT growth and GDP growth, which are shown in particular countries such as Poland, Slovak Republic, Bulgaria, Hungary, Turkey and Slovenia. As seen from the Figure 5, Portugal, Spain, Greece, Cyprus, Austria and Germany nearly match with the pattern. This pattern is, to a large extent, consistent with the view of Dewan and Kraemer's (2000), that is, *ICT has been beneficial only for developing countries*. Indeed, the first group countries lining up in the Figure 5 are relatively new member countries of the EU and Turkey. The effects of these increases on the GDP growth may be observed much more due to the fact that these countries have a relatively weaker ICT structure.

Figure 5: The relationship between ICT and growth between 1997-2014 periods.



3.1. Data & Model

In this study the contribution of ICT on economic growth is examined within the framework of Solow model and the seminal paper of Barro (1991). To determine some several policy variables like the effect of government, financial intermediaries, and social inequality and trade are one of the advantages of this model (Vu, 2011: 364). The impact of ICT on economic growth is measured for EU-28 countries and Turkey for 1997-2014 periods. The model given below:

$$YGROWTH_{it} = \alpha + \beta X_{it} + \varepsilon_{it} \qquad (E.1)$$

In (E.1), $YGROWTH_{it}$ symbolys GDP per capita growth rate, X_{it} is a vector for all explanatory variables. ε_{it}, is the error term of the model. There are six major variables used in this study in place of X_{it} which affect economic growth. These variables are shown in Table 1 below:

Table 1: Description of Variables in Model

Variables	Definition	Unit
$YGROWTH_{it}$	GDP per capita growth (annual %)	%
$ICTfixphone_{it}$	The growth rate of Fixed telephone subscriptions (per 100 people)[a]	%
$ICTInternet_{it}$	The growth rate of Individuals using the Internet (per 100 people)	%
$ICTmobile_{it}$	The growth rate of Mobile telephone subscriptions (per 100 people)[a]	%
$GFCF_{it}$	The growth rate of gross fixed capital formation (% of GDP)	%
$trade_{it}$	The growth rate of trade (% of GDP)	%
$population_{it}$	Population growth rate (annual %)	%

Source: WDI Online DataBank (2018).

The model in the light of these considerations is then established as shown below:

$$YGROWTH_{it} = \alpha_0 + \beta_1 ICTfixphone_{it} + \beta_2 GFCF_{it} + \beta_3 trade_{it} + \beta_4 population_{it} + \varepsilon_{it} \qquad (E.2)$$

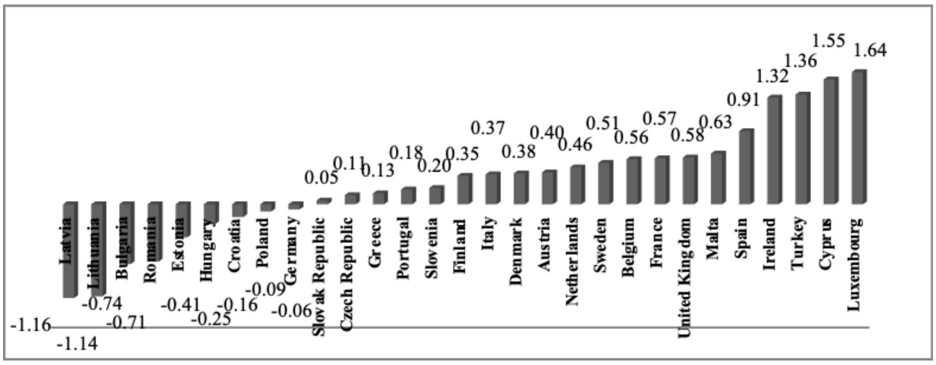
$$YGROWTH_{it} = \alpha_0 + \delta_1 ICTInternet_{it} + \delta_2 GFCF_{it} + \delta_3 trade_{it} + \delta_4 population_{it} + \xi_{it} \qquad (E.3)$$

$$YGROWTH_{it} = \alpha_0 + \gamma_1 ICTmobile_{it} + \gamma_2 GFCF_{it} + \gamma_3 trade_{it} + \gamma_4 population_{it} + \zeta_{it} \qquad (E.4)$$

In these equations; $YGROWTH_{it}$ is the GDP per capita growth (annual %); $GFCF_{it}$ is the growth rate of gross fixed capital formation (% of GDP); $population_{it}$ is population growth (annual %). $trade_{it}$ is the growth rate of trade (% of GDP). In the estimation procedure, we adopted the same methodology with Becchetti and Adriani (2005) and Vu (2011) tried to analyze the effect of ICT on growth with three different variables respectively. In this study $ICTfixphone_{it}$ symbolises the growth rate of fixed telephone subscriptions (per 100 people); $ICTInternet_{it}$ is substitute for the growth rate of individuals using the Internet (per 100 people) and $ICTmobile_{it}$ is the growth rate of mobile telephone subscription (per 100 people). Expected signs for all variables are positive except population. But the difference between Vu (2011) and our analysis is that we did not take the penetration rates, rather we take ICT penetration growth rates as given in Table 1. However, another deficiency of our study is the absence of the education data.

According to the growth theory of Solow, population growth has a positive impact on economic growth. As seen from Figure 6, the average of growth rates in this study are barely negative (e.g. for Latvia -1.16; Lithuania-1.14; Bulgaria -0.74; Romania –0.71; Estonia -0.41; Hungary -0.25; Croatia -0.16; Poland -0.09; Germany -0.06) and almost all population rates are not increasing.[4] Indeed, it is generally expected that the studies on the relationship between population growth rate and economic growth show negative results.

Figure 6: Annual Average Population Growth Rate (1997-2014)



Source: WDI Online DataBank (2018)

[4]Austria, Czech Republic, France, Finland, Ireland, Luxemburg, Sweeden and UK may serve extensions for this argument. The decreasing tendency in this context is valid for these countries even if there is a rise in the population of them (WDI Online DataBank, 2018).

3.2. Econometric specification and estimation results

In this paper panel data estimation method is employed in the empirical analysis. Panel data consists of time-series and cross-sectional observations. Panel data analysis has many advantages over time-series and cross-section. Some of these advantages are identified as follows: a better choice for controlling the heterogeneity effects among groups; enabling the decrease of a multiple linkage among explanatory variables; enhancing the sensitivity and effectiveness of the estimation procedures in econometrics (Hsiao, 2003; Baltagi, 2008).

In general, three methods are followed to combine the (static) data. (1) Unconditional pooled model (ordinary least squares); (2) The fixed effects model (FEM); and (3) The random effects model (REM). There are various views about the choice of the fixed or the random effects model. Hsiao, leaves the choice to researchers in determining the fixed or the random model regarding to the effects in the sample (Hsiao, 2003: 43). However, if the sample is not taken from a special field, the random effects model is preferred. According to Greene, if there is a comparative analysis and the analysis covers all the countries, or the sample is selected from a big population, the fixed effects model is, in this case, the most appropriate choice. As a result, the content of the data in this process and the methods in obtaining them is important (Greene, 1997: 623). Indeed, in this study the results of fixed effects are considered more reassuring because of the results of Hausman test and the fact that a specified fixed group as a sample is incorporated into the analysis.

In some cases, auto-regressive models are required to apply in panel data analyses. Moreover, a dynamic panel data model is even one of the best alternatives in this particular analysis. There are many problems concerned with the data in the field of economics such as serial correlation, heteroscedasticity and endogeneity of some of the explanatory variables. One of best solutions in addressing these problems can be found in the methods of Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond’s (1998, 2000), GMM first-differenced (GMM-FD) estimator and the GMM system (GMM-SYS) estimators. These estimators have been applied to different economic data by a group of economists such as Papaioannou and Dimelis (2007); Faustino and Leitao (2007a; 2007b); Thorpe and Leitao (2012). As a result of that, unbiased and consistent results have been obtained.

Dynamic panel data may be estimated in different ways GMM and also with Bias Corrected Least Squared Dummy Variables (LSDV-BC). In this analysis two GMM procedures are applied. After that, we run the LSDV-BC estimation which is used by Bruno (2005). Monte-Carlo experiments show that this approach can be used by small data samples or even for micro panels Kiviet (1995) and Bun and Kiviet (2001). Therefore, the results of the empirical analysis have been based on static and dynamic panel data estimators.

Table 2: Link between ICT-fixphone growth & GDP growth

Dependent variable: $YGROWTH_{it}$						
	$YGROWTH_{it-1}$	C	$ICTfixphone_{it}$	$GFCF_{it}$	$trade_{it}$	$population_{it}$
OLS	-	1.730*** (.294)	.066** (.026)	.224*** (.015)	.008*** (.003)	-1.030*** (.170)
RE	-	1.929*** (.429)	.072*** (.033)	.229*** (.066)	.006* (.004)	-.950*** (.248)
FE	-	3.293** (1.539)	.061** (.028)	.234** (.080)	-.007 (.014)	-.829* (.422)
GMM-FD[a]	.132 *** (.039)	-	.064* (.034)	.284*** (.034)	-.0179*** (007)	-.829* (.497)
GMM-SYS[b]	.060 (.042)	-	.090 (.077)	.363*** (.043)	-.018 (.012)	.043 (.450)
LSDV-BC	.250*** (.044)	-	036 (.030)	.250*** (.017)	-.005 (.009)	-.869*** (.312)

Notes: Standard errors are reported in brackets. For FEM Driscoll/Kraay standard errors. For REM, GMM-FD & GMM-SYS robust standard errors and for LSDV-BC bootstrapped standard errors estimated. ***, ** and * are significance at 1%, 5% and 10%. [a]Arellano-Bond test result for second order correlation is -1.16 and p-value is 0.2461. [b]GMM-SYS estimated by robust estimator. Arellano-Bond test result for second order correlation is -0.78 and p-value is 0.435.

The results obtained from Equation (2) are shown in Table 2. First of all; we presented the results of OLS estimation. OLS estimation was used only for a comparison as usual. When we test our variables with specification tests, we can see that the problems such as heteroskedasticity, autocorrelation and cross-sectional dependence are present.

Then we gave the random effect estimator Arellano, Froot& Rogers. For GLS, we use Arellano, Froot& Rogers estimators for GLS estimation. We found a X^2 coefficient, which is 10.96 with 0.0271 $prob > X^2$ for Hausman type-test, which implies a fixed effect estimator. Similarly, we expect same results since we collect our data from a well-known sample, EU countries. According to the theoretical approaches of Hsiao (2003) and Greene (1997), if a certain example is selected within a special cluster, it can be evaluated through a fixed effect model. But from a comparative perspective we prefer within estimator with random effect GLS estimator. The results of GLS estimator show a positive correlation between ICT fixed telephone growth variable and economic growth. GFCF and trade growth variables also affect growth positively, as seen from Table 2, and all of these results are significant. As expected, only the population growth variable affects growth significantly, though negatively. The reason may be interpreted as the declining ratio of growth for most of the countries in our sample.

We run Driskool-Kraay estimator for the fixed effect model. This estimator also provides robust results for this kind of data (Hoechle, 2007). The results of Driskool-Kraay within estimator show that ICT fixed telephone, GFCF and trade growth affect economic growth positively, as expected. Population variable also affects growth negatively here. All variables are significant at least at 10% level, except trade.

In addition, we run dynamic panel data regressions. First, we run GMM-FD of Arellano and Bond (1991) and GMM-SYS estimators of Arellano and Bover (1995) and Blundell and Bond's (1998, 2000). However, our Arellano-Bond first difference estimator (GMM-FD) suffers from too many instrumental variable problems. As Roodman (2007) stated, the quotient of number of cross-section units by number of instrumental variables cannot be lesser than one. In our case, it is much lesser than one. So, we try to run LSDV-BC estimator to avoid this problem. Although LSDV-BC reaches prosperous results for our model but as far as we know that there is no any robust estimator for LSDV-BC. So, the robust GMM-FD estimation results show that ICT fixed telephone variable affects growth positively, as expected. And also, lagged economic growth and GFCF growth have a positive effect on growth as expected. Population variable also has a negative effect in here. However, trade variable shows a negative effect in this estimation. Finally, all variables are statistically significant at least 10 % level. In robust GMM-SYS estimation GFCF is the only variable, which is statistically significant. GFCF growth affects economic growth positively, as expected. As is seen from Table 2, 3 and 4 the results of both GMM estimators are quite contradictory. This is because “weak” instrument problems affecting GMM-FD, and GMM-SYS estimators suffer from “too many” instruments (Hayakawa, 2007).

In this regard, we gave place to a different type of dynamic estimator, LSDV-BC, which may lead to prosperous results in small sample case. The last line shows LSDV-BC results. This estimation procedure shows that lagged growth, ICT fixed telephone and GFCF variables affect economic growth variable positively. However, in this model, ICT fixed telephone is not statistically significant. Population growth rate shows a negative effect on growth, which is the same with previous results. Trade growth rate is not significant in this analysis.

Table 3: Link between ICT-internet growth & GDP growth

Dependent variable: $YGROWTH_{it}$						
	$YGROWTH_{it-1}$	**C**	$ICTInternet_{it}$	$GFCF_{it}$	$trade_{it}$	$population_{it}$
OLS	----	1.272*** (.312)	.011*** (.003)	.224*** (.015)	.009*** (.003)	-1.055*** (.169)
RE	-	1.451*** (.424)	.010*** (.004)	.229*** (.067)	.008*** (.003)	-1.005*** (.249)
FE	-	2.942* (1.684)	.008 (.005)	.234*** (.078)	-.006 (.015)	-.896* (.433)
GMM-FD[a]	.133*** (.039)	-	.012*** (.004)	.284*** (.034)	-.014* (.008)	-.869* (.470)
GMM-SYS[b]	.054 (.044)	-	.030** (.013)	.356*** (.042)	.002 (.013)	.082 (.453)
LSDV-BC	.248*** (044)	-	.010** (.004)	.249** (.016)	.002 (.009)	-.927*** (.308)

Notes: Standard errors are reported in brackets. For FEM Driscoll/Kraay standard errors. For REM, GMM-FD & GMM-SYS robust standard errors and for LSDV-BC bootstrapped standard errors estimated. ***, ** and * are significance at 1%, 5% and 10%. [a]Arellano-Bond test result for second order correlation is -1.26 and p-value is 0.2070. [b]GMM-SYS estimated by robust estimator. Arellano-Bond test result for second order correlation is -0.73 and p-value is 0.466.

Table 3 displays the effect of internet usage on growth, and they show the results from estimating Equation (3). Therefore, ICT internet growth variable is the explanatory ICT variable here. In this model specification tests show also heteroskedasticity, autocorrelation and cross-sectional dependence. In this case we analyzed fixed effect model with Driskoll&Kraay and random effects model with Arellano, Froot& Rogers. Hausman test still points out fixed effect model (X^2 is 15.82 with 0.0033 $prob > X^2$). Within estimator shows that GFCF and population growth are the only significant variables, which means that physical capital affects growth positively as expected. When we return to evaluations above, we see that population variable affects growth negatively as expected. Driskoll&Kraay estimation results show that there is no correlation between internet usage and growth. In random effect model (Arellano, Froot& Rogers) all variables are significant and all of then show the expected sings.The GLS estimator verifies the positive effect of ICT internet variable on growth.

The last three rows of Table 3 include dynamic panel data estimators. GMM-FD results show that all variables are significant at least 10 % level and all of them are in expected signs, except trade growth. Here, internet usage growth rate has a positive effect on growth as expected and also lagged growth variable, and physical capital growth (GFCF) has an positive effect. According to (robust) GMM-FD estimation results, trade variable which is a proxy for country's openness affects growth negatively and unexpectedly. And population growth rate once again has a negative sign here too. After GMM-FD, we runned (robust) GMM-SYS estimators. Therefore, internet usage growth rate ($ICTInternet_{it}$) has an positive and significant effect on growth. GFCF and is the other significant variables which affect economic growth positively. In GMM-SYS lagged growth, trade and population growth did not show any significant effect on growth.

Table 4: Link between ICT-mobile growth & GDP growth

Dependent variable: $YGROWTH_{it}$						
	$YGROWTH_{it-1}$	**C**	$ICTmobile_{it}$	$GFCF_{it}$	$trade_{it}$	$population_{it}$
OLS	-	1.616*** (.308)	.003 (.002)	.226*** (.016)	.008*** (.003)	-1.02*** (.172)
RE		1.881** (.438)	.002 (.004)	.231*** (.066)	.006* (.003)	-.952*** (.261)
FE	-	3.878*** (1.58)	-.0002 (.003)	.237*** (.078)	-.014 (-.014)	-.836* (.427)
GMM-FD[a]	.126*** (.038)	-	.013* (.007)	.279*** (.035)	-.012 (.008)	-.676* (.404)
GMM-SYS[b]	.054 (.043)	-	.018 (.013)	.355*** (.045)	-.011 (.014)	.141 (.465)
LSDV-BC	.249*** (044)	-	008 (.005)	.244*** (.017)	-.0002 (.009)	-.826*** (.313)

Notes: Standard errors are reported in brackets. For FEM Driscoll/Kraay Standard errors. For REM, GMM-FD & GMM-SYS robust standard errors and for LSDV-BC bootsrapped. Standard errors estimated. ***, ** and * are significance at 1%, 5% and 10%. [a] Arellano-Bond test result for second order correlation is -1.2177and p-value is 0.2233. [b] GMM-SYS estimated by robust estimator. Arellano-Bond test result for second order correlation is -0.90 and p-value is 0.366.

The effect of mobile telephone usage growth rate on economic growth has been analysed by means of Equation 4. Here, once again, the results of Hausman test point out FEM (X^2 is 20.03 with 0.0005 $prob > X^2$). When Table 4 is examined, it can be said that ICT mobile variable has a negligible effect on growth. This variable is only significant for Arellano-Bond's (robust) GMM-FD estimation. For the rest of the analysis, it is totaly insignificant. Physical capital growth rate (GFCF) is the only variable which is significant in all of the six estimation procedures. This variable has a positive effect on growth as expected. While population variable is significant in all estimations except (robust) GMM-SYS, it has a negative effect on growth, and this is not suprising. Except OLS and Arellano, Froot& Rogers's GLS estimations, trade does not have a significant effect on growth.

As mentioned above, we had to overcome the autocorrelation, heteroskedasticity and cross-sectional dependence problems at first.

According to preliminary test results, the problems of heteroskedasticity, serial correlation and cross-sectional dependence were detected in the series. Thus, we used Driscoll-Kraay for FEM and Arellano-Froot& Rogers for REM. However, Hausman test results show FEM for all equations. After that, we applied dynamic panel data estimators which are Arellano and Bover's (1995) GMM first-differenced (GMM-FD) estimator, Blundell and Bond's (1998, 2000), GMM system (GMM-SYS) and LSDV-BC estimation which is recently demonstrated by Bruno (2005).

The effect of three different variables ($ICTfixphone_{it}$, $ICTInternet_{it}$, $ICTmobile_{it}$) concerned with ICT (growth rate) on economic growth were observed in three different equations. The effect of fixed telephone variable ($ICTfixphone_{it}$) on economic growth for static panel data estimators is, as expected, statistically positive and important. For dynamic panel data analysis, the Arellano-Bond (1991) GMM-FD and Arellano and Bover (1995) with Blundell and Bond (1998; 2000) GMM-SYS estimators were taken place. In addition, LSDV-BC was applied because the number of panel data observation (28*18=504) was relatively small. As a result of the dynamic panel data, it is determined that there is positive and significant relationship between fixed telephone variable and economic growth for only GMM-FD. In equation 3, the effect of internet variable ($ICTInternet_{it}$) on economic growth is analysed. The effect is positive and statistically significant for all estimators whether it is static or dynamic, apart from Driscoll-Kraay. However, the effect of growth rate of mobile telephone use on economic growth is significant for only one (GMM-FD) of six estimators.

GFCF growth rate is significant for all model and estimators, and, as expected, its effect on economic growth is positive. Population growth rate for all estimators (except GMM-SYS) significant and its effect on economic growth is, as expected, negative. The results related to trade growth rate is controversial. Although this variable is not generally significant, its results varies between positive (REM) and negative (GMM-FD) for different estimators. The reason of these differences observed between static and dynamic panel data analysis, as indicated in the analysis section of this paper, might be that the number of instrumental variables seen in the dynamic estimators is far more than the number of cross-section units.

To sum up, the main outcome of this study is that the effect of ICT variables on economic growth is positive. These results cannot only be confirmed with the variable of $ICTmobile_{it}$. As Jacobsen (2003) puts it, the most important reason for this result is that the use of mobile telephone or its growth rate does not have an impact on economic growth after a certain stage.

4. Conclusion

The sources of economic growth have always been an important discussion subject in the literature of economics. Over the time the indicators like foreign trade, openness degree of economy and human capital have become relevant in explaining economic growth. In recent years ICT as a trendy subject have, in particular, come to fore for an investigation of whether knowledge technologies and the investments made to this area affect economic growth.

This paper is related with the inquiry of whether ICT affects economic growth for the EU 28 (Malta excluded) countries and Turkey in the period of 1997 and 2014. The contribution of ICT growth rate on economic growth is examined within the framework of Solow model. To investigate this relationship, static and dynamic panel data analysis are applied. The results of two different models which are fixed telephone subscriptions and internet variables show that ICT penetration growth rate that has a positive effect on growth, needs to be taken into account. Our analysis could not reveal any robust relationship between ICT_{mobile} variable and growth. These results except the variable of mobile telephone are, to large extent, consistent with the relevant literature. However, many researchers like Jacobsen (2003), Waverman et al. (2005), Gruber and Koutroumpis (2011), Vu (2011) and Farhadi et al. (2012) found a positive correlation between mobile telephone and economic growth. The difference of our analysis is that we took mobile telephone penetration growth rate like Becche tti and Adriani (2005) rather than taking the mobile telephone penetration rate. Besides, for almost all countries, mobile telephone penetration does not increases after a threshold, rather decreases, and even it is negative for most countries mostly since 2009. In the research of

Jacobsen (2003) it is highlighted that the benefit of countries from telecommunication declines when the initial level of mobile telephones rises.

It can briefly be said that ICT is one of the important drivers of economic growth. It is also observed that physical capital growth has an important positive impact on economic growth while population growth has a negative effect due to decreasing rates. The effect of trade growth on economic growth is one of the heterotaxic issues of our analysis. It is not significant for the most of our regressions, and where it is significant its impact differentiates between positive and negative.

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