THE EFFECT OF INFORMATION AND COMMUNICATION TECHNOLOGIES ON ECONOMIC GROWTH IN OECD COUNTRIES

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Abstract:
The objective of the present study is to investigate the effect of information and communication technologies on economic growth. For this purpose, telecommunications infrastructure investments, number of Internet and telephone subscribers and human capital figures of 34 OECD countries between 1968 and 2013 were utilized to conduct an unbalanced panel data analysis. Study findings demonstrated that number of Internet and telephone subscribers increased per capita growth rate.

Keywords: General economy, international economy, economic growth, national economic studies.

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1. Introduction

There are several previous studies that measured the correlation between public expenditures and economic growth. Literature review would demonstrate that there was an increase in such studies especially after the second half of the 19th Century. In a study conducted by Oxley (1994) in the United Kingdom, it was determined that the increase in public expenditures had a booster effect on national income. Also Iyare and Lorde (2004) conducted a similar study in 9 Caribbean countries. Booster effect of public expenditures on national income was apparent in this study as well. In addition, Abizadeh and Gray (1985) investigated the relationship between public expenditures and economic growth. Study results showed that the increase in public expenditures increased economic growth in developing countries, however, the same was not true for undeveloped and developed countries based on the study findings. On the contrary, they found that a decrease in public expenditures increased economic development in developed countries. In short, abovementioned studies demonstrated that infrastructure investments had positive effects on economic growth. Furthermore, there are several other studies that evidenced the growth of this sector due to investments in information and communication technologies also had positive impact on economic growth. These studies are significant for adequate identification of public policies. Because, the rapid technological advances of the last twenty years affected the economic growth of nations positively. Especially, as a result of application of information and communication technologies in business processes, restructuring of operational practices in business, and improvement of business processes and labor productivity, considerable contributions were obtained. In the current level of globalization, countries that develop and utilize information and communication technologies were able to increase both economic and social levels of development. Also in this respect, scrutiny of the topic is important.

Main topic of the present study is the analysis of the correlation between public expenditures and economic growth, especially based on information technologies investments. In the next section of the study, studies that established the relationship between public expenditures and information and communication technologies investments and economic growth are investigated in the literature. Using the economic model developed as a result of the conducted literature review, a panel data analysis is conducted using 1970-2013 data for 34 OECD countries. Recommendations and policies developed as a result of the abovementioned analysis are discussed in the final section.

2. Literature Review

There are several studies that provided positive results about the positive impact of infrastructure investments on economic growth in economic literature. However, it should be considered that different infrastructure types would

have different contributions to the economic growth. It is beneficial to address especially the results of infrastructure investments in information and communication technologies for public platform with respect to the significance of government policies. In the literature review, immediately after the findings of the studies that discussed the effect of infrastructure investments on economic growth, studies related to infrastructure investments in information and communication technologies will be scrutinized. Because, although there are several studies in economic literature that investigated the effect of infrastructure investments on economic growth, there are only a few that measured the impact of infrastructure investments in information and communication technologies on economic growth.

Hardy (1980) conducted one of the first studies that investigated the potential effect of communications investments on economic growth. Using data for 15 developed and 45 developing nations and more between 1960 and 1973, Hardy reduced per capita GDP to lagged per capita GDP, lagged per capita telephone and radio count. Hardy reported that lagged per capita number of telephones had significant impact on GDP, however the effect of the radio penetration had no effect. But, when regression was applied separately for developed and undeveloped countries, it was found that the penetration of radio also affected growth significantly. It was noted that this could be explained by the presence of fixed effects. However, Hardy's study addressed neither fixed effects nor the reverse causality problems.

Madden and Savage (1998) examined the correlation between telecommunications investments and economic growth in OECD member Central and Eastern European countries. In the study, it was stressed that insufficient telecommunications investments in these countries should be increased in these countries to improve international trade and regional productivity. In their study, Madden and Savage (2000) researched the correlation between economic growth and telecommunications in 43 countries by adding telecommunications investments to the Cobb Douglas production function in Mankiw's growth model. They utilized landline phone data as telecommunications indicator. As a result, they determined that increases in economic growth and international trade were positively affected by telecommunications investments. Röller and Waverman (2001) investigated the correlation between economic growth and telecommunications infrastructure investments in 21 OECD countries using data for 20 years between 1970 and 1990. Study findings demonstrated a positive correlation between economic growth and telecommunications investments. Datta and Agarwal (2004) studied how telecommunication infrastructure investments affected economic growth in the long-run in 20 OECD countries using dynamic panel analysis. Telecommunications investments were measured with number of telephone lines per 100 people in the study. Study model also investigated the relationships between consumption expenditures, population increase, openness of the country, past GDP and lagged growth. It was found in the study that telecommunication infrastructure investments affected economic growth positively in the long-run and the countries that increased these investments would gain further economic growth impetus. Also, S. W. Norton (1992) conducted a more complete analysis of the correlation between communications and economic growth. Norton estimated the effect of mean number of telephones on annual growth rate using 47 country data between 1957 – 1977 by controlling it for the number of telephones in 1957 and a series of macroeconomic variables. Norton found that the communications variable was positive and significant and decided that the presence of a communication infrastructure decreased operational costs due to increased output when "the infrastructure is present." Furthermore, Norton also predicted that Burma, Honduras, Sri Lanka and Bolivia would have higher growth rates with the existing coefficients and if they had the penetration rates of Mexico and Canada. Zahra, Azim and Mahmood (2008) investigated the effect of the development in communications infrastructure on economic group using panel data analysis in their study. The study was conducted with 1985-2003 data collected from low, medium and high income group countries. In the study, the relationships between economic growth and fixed investments, population growth, public expenditures and communications infrastructure investments were scrutinized in the examined nations. Authors concluded that communications infrastructure investments significantly increased economic growth in the study.

Ding, Haynes and Liu (2008) researched the correlation between telecommunications investments and regional growth in 29 Chinese regions during 1986-2002. A significant and positive correlation between economic growth and telecommunication investments was found at the end of the study. Röller and Waverman (2014) analyzed the correlation between telecommunications infrastructure and economic growth in 21 OECD member countries using synchronic analysis technique for 1970-1990. At the end of the study, it was found that telecommunications investments affected economic growth function positively.

Farhadi and Ismail (2014) investigated the impact of information and communication technologies on economic growth in 142 countries for the period of 2000-2009. Information and communication technologies were measured by telephone and Internet penetration. It was stressed that economic growth was further triggered in high income group countries due to easy Internet access. The authors recommended medium and low income countries to adopt policies that would promote Internet access. Finally, Shane Greenstein and Pablo T. Spiller (1996) investigated the effects of communications infrastructure in the USA (number of fiber optic cable and ISDN lines) on economic performance. They determined that infrastructure investments increased local communications services and thus, increased the number of users, which in turn caused a growth in trade income. In short, abovementioned studies provide evidence that communications investments had positive effects on the output.

3. Data and Methodology

In this section, we will investigate the correlation between communications infrastructure investments and economic growth. Similar to several studies found in the literature, the present study uses data for a 43 year period between 1970 and 2013 for 34 OECD member countries. Obtained data include general economic variables and country specifications.

Constructed economic model was as follows:

$$GDP_{it} = \beta_1 HC_{it} + \beta_2 INTER-USER_{it} + \beta_3 INVEST_{it} + \beta_4 TEL-USER_{it} + v_{it}$$

Table no 1. Variables used in the model

GDP	Per Capita GDP
Independent Variables	
HC	Human Capital
INTER-USER	Number of Internet Users
INVEST	Telecommunication Investments
TEL-USER	Number of Telephone Users

To figure out whether the variables used in the model contained unit root, Im, Pesaran and Shin unit root test was utilized. Unit root test results for the variables are presented in Table 2.

Table no 2. Im, Pesaran and Shin unit root test results

Variables	**With Constant**		**With Constant & Trend**	
	t statistic	**p value**	**t statistic**	**p value**
GDP	18.9417	1.0000	6.05990	1.0000
HC	5.57735	1.0000	1.96414	0.9752
INTER_USER	8.63844	1.0000	0.11408	0.5454
INVEST	5.44068	1.0000	4.11301	0.0000
TEL_USER	3.56821	0.9998	1.18972	0.1171

Results displayed in Table 2 shows that all series with the exception of with constant and with trend models of INVEST variable had unit root. Thus, it was accepted that all series with the exception of INVEST had unit roots and first differences of the series were taken. Following this process, unit root test was applied to first differences and found that the series did not contained unit root.

3.1. Model Estimation Findings

It was observed that fixed effect model was adequate for the model. Estimation results for the model are given below.

Table no 3. Model estimation results
(dependent variable: GDP) method: panel least squares (fixed effect)

Variable	Coefficient	Std.Error	t-Statistic	Prob.
HC	0.003874	0.002698	1.435999	0.1524
INTER_USER	0.006612	0.001234	5.356608	0.0000
INVEST	-0.004774	0.003849	-1.240426	0.2162
TEL_USER	0.001735	0.000721	2.407157	0.0169
C	9.647250	0.109666	87.96964	0.0000

R-squared 0.975401
Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	144.568522	(26,216)	0.0000
Cross-section Chi-square	719.374327	26	0.0000

It was determined that the most suitable model was fixed effect model. Based on this model, an increase in the number of Internet and telephone users significantly increased GDP. It was observed that human capital and telecommunications variables did not display significant effects.

Table no 4. Panel data heteroscedasticity hall-pagan test

Ho: Panel Homoscedasticity - Ha: Panel Heteroscedasticity				
- Hall-Pagan LM Test: E2 = Yh	= 0.9321	P-Value	Chi2(1)	0.3824
- Hall-Pagan LM Test: E2 = Yh2	= 0.0427	P-Value	Chi2(1)	0.7486
- Hall-Pagan LM Test: E2 = LYh2	= 1.0328	P-Value	Chi2(1)	0.3618

Table no 5. Beusch-Gdfrey/Wooldridge test for serial correlation in panel models

data: gdp ~ inter_user + hc + tel_user + invest
chisq = 68.85, df = 1, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors

While there is no variable variance problem in the model based on the results of the above diagnostic tests, an autocorrelation problem existed. Thus, to remove the autocorrelation problem, model was estimated again using different estimators. In the below table, fixed effect 1 model depicts the normal estimate of the model, fixed effect 2 model reflects re-estimated results with Huber-White variance estimator when both autocorrelation and variable variance were present in the model, fixed effect 3 model reflects the re-estimated model to remove the autocorrelation when only autocorrelation was present, and fixed effect 4 model depicts the final re-estimated status of the model when autocorrelation section dependency and variable variance were both present. Since there was only autocorrelation problem in our model, we have considered the results of the fixed effect 3 model.

Table no 6. Results for fixed effect models

Variable	Fixed Effect 1	Fixed Effect 2	Fixed Effect 3	Fixed Effect 4
HC	.00387	.00387	. 0396***	.00387
INTER_USER	.00661***	.00661***	.0107*	.00661***
INVEST	-.00477	-.00477	.0737***	-.00477
TEL_USER	.00174*	.00174	.00649*	.00174
Cons.	9.65***	9.65***	6.75***	9.65***
r2_w	.661	.661	.397	.661
F	105	54.3	31.4	33.9

---------- **Explanation:** * p<0.05; ** p<0.01; *** p<0.001

Thus, based on the above fixed effect 3 model results, it could be observed that increases in the number of Internet users, human capital and fixed capital investments increased per capita annual growth rate. Therefore, it could be deducted that development of the logistics industry has a positive effect on per capita annual growth rate.

3.2. Panel Cointegration Tests

Despite the permanent shocks between the variables that affect the system, existence of a balance relationship in the long-run was possible. This relationship should be tested. Similar to panel unit root tests, the advantage of using panel cointegration tests when compared to applying cointegration tests to the time series is the increase in the test power. These tests are Kao panel cointegration tests, Pedroni panel cointegration tests, McCoskey and Kao panel

cointegration tests and Westerlund panel cointegration tests. In the present study, Westerlund panel cointegration tests were used. Westerlund panel cointegration tests were based on four statistics and are quite flexible and allows for the heterogeneity in the long and short term parameters of error correction model. If there is a possibility of correlation between the units, resistant critical values are obtained with self-inference.

Table no 7. Model cointegration test results

Kao Residual Cointegration Test
Series: GDP HC INTER_USER INVEST TEL_USER
Date: 06/17/15 Time: 03:31
Sample: 3920 3973
Included observations: 1836
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
User-specified lag length: 1
Newey-West automatic bandwidth selection and Bartlett kernel

	t-Statistic	Prob.
ADF	-2.655453	0.0040

Model cointegration result demonstrated that there was a co-integrative correlation in the long term between GDP HC INTER_USER INVEST TEL_USER variables. In other words, these variables act together in the long-run.

4. Recommendations and Policies

In today's economies where technological advances are rapid and continuous, access to information and the presence of communications networks could render the expectation management in economies a controllable magnitude. Especially the existence of public and private sector investments in information and communication technologies could increase the prospects of growth related policies. Infrastructure and development investments in information and communication technologies could provide an opportunity of reaching their targets in growth for the political governments. Within this context, in the present study that investigated the effects of information and communication technologies on economic growth in OECD country groups, it was observed that the contribution of infrastructure investments was undeniably high. Furthermore, the presence of telephone and Internet services investments that provide the possibility of utilizing the communications networks provide positive contribution to the economic growth. Similarly, the existence of cointegration correlation was another finding that reflected the fact that economic growth and information and communication technologies investments and those who benefit from these investments were related in the long term. Thus, the existence of investments in information and communication technologies creates a positive effect on economic growth.

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