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TEKPOL Working Paper Series

09/03

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Abstract
This paper tests the impact of ICT on economic growth for underdeveloped and developing countries by using a panel dataset for the period of 1995-2006. We first develop the theory of the relationship between ICT and economic growth. We show that ICT-capital has a positive effect both on long-run and transitional income per capita, if it is considered as a factor of production. Next, we estimate a panel data set with 131 underdeveloped and developing countries under the assumption that ICT is one of the determining factors of economic growth. We find that ICT has positive and significant effect on economic growth even after the use of some control variables.

***Keywords*:** ICT, economic growth, Panel Data, GMM
JEL Classification: C33, O5, O33.

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1. Introduction

In the mid 1990s and early 2000s, a popular, but unsubstantiated belief was that information and communication technologies (ICT) would change the world so quickly that the world would witness rapid (and perhaps sustainable) growth and productivity gains in the years to come.[1] This belief caused a big bubble in the world economy and especially in the US economy. In 2001, the bubble burst and the world has since returned to a "brick-and-mortar" economy.[2] It was soon realized by many that the ICT revolution was just a bubble from the stock market dimension. The negative experience of the stock market, however, stressed only the speculative aspects of the ICT revolution. In fact, the ICT revolution led to positive concrete changes in the real economy. In particular, it created a huge goods and services economy with strong forward and backward linkages. Given its overwhelming impact, the ICT revolution has begun to be classified by many economists as a general-purpose technology, as in the case of steam engine and electricity.[3]

Many economists consider ICT a general-purpose technology due to its pervasive character: it has already become an indispensible part of production of goods and services, irrespective of industry. The literature has identified two important channels by which ICT can have real effects on real economy: production of ICT and the use of ICT (by other industries). Firstly, the ICT sector itself has rapidly become an important industry at global level coinciding with the growth of the service industries. Processors, RAMs, hard disks, motherboards, desktops, notebooks, and super-computers are just few items that ICT industry produces. It is estimated that the global marketplace for ICT will exceed $3.7 trillion in 2008 and $4 trillion by 2011 (WITSA, 2008). In short, the ICT production sector is very important for real economy as this industry (i) nourishes GDP, (ii) increases its share in GDP due to the characteristics of this industry: rapid technological progress, strong and persistent demand, falling (relative) prices, rising quality, and increasing product variety.

Secondly, ICT revolution has contributed significantly to the whole economy by raising productivity. First, ICT increases labor productivity in ICT-using industries by simply making labor more productive (c.f., van Ark *et al*. (2003) and Matteucci (2005)). For example, a secretary can handle the same office tasks in a shorter period due to the ICT revolution. Second, ICT makes physical capital more productive (c.f., Röller and Waverman (2001)). A good example is the computer numerical control (CNC) machine, which has increased productivity of physical capital in all manufacturing industries since its use.[4] All in all, the ICT revolution had led to significant productivity increases in the ICT-using industries.

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[1] We use Information and Communications Technologies (ICT) as an umbrella term to include all technologies used for the manipulation and communication of information. We believe that ICT encompasses the term Information Technology (IT), though sometimes the two are used interchangeably.

[2] The bubble covered approximately 1995–2001 and generally coined 'dot-com bubble', as the newly founded Internet-based companies was the main characteristic of the period. During the bubble, venture capital was widely available and, in consequence, stock prices increased rapidly.

[3] General purpose technologies, also called drastic technologies, describe great leaps of innovation that can affect the global economy. Examples are the steam engine, railroad, and electricity. Since Kondratieff (1926), many researchers, including Schumpeter (1939), Mensch (1979), van Duijn (1983), Kleinknecht (1987), and Mokyr (1990) contributed to the issue by identifying their main characteristic that drastic technological changes generally appear in clusters and leaps. Relatively recently, David (1990) and especially Bresnahan and Trajtenberg (1995) made the term general-purpose technology (GPT) popular again. Many, e.g., Helpman (1998), consider that ICT is the general-purpose technology of modern times.

[4] Computer numerical control (CNC) is a computer 'controller' that drives a powered mechanical device typically used to fabricate components.

The discussion presented above however fails to address the issue of how individual economies are affected by the 'ICT revolution'. In particular, we need to know whether developed and developing countries benefit homogenously from the ICT revolution. The curiosity arises from the general observation that underdeveloped and developing countries do not have a sizeable ICT producing industry and may not have the capacity to absorb full benefits of using ICT. Firstly, ICT production is concentrated in few countries (e.g., U.S., Ireland, China, and Taiwan). Much of the rest of the world, including all African, Latin America and many Asian countries, have no physical capacity to produce ICT. In this respect, ICT products are nothing but imported goods for the majority of underdeveloped and developing countries. Secondly, human capital and physical capital is a scarce factor of production for a majority of underdeveloped and developing countries. In this respect, these countries may not able to exploit the full benefits of using ICT as they lack proper and sufficient amount of human and physical capital that complements the ICT revolution. This observation raises curiosity as to the different extents to which underdeveloped and developing benefits from the ICT revolution.

We believe that a good macro variable that may verify whether underdeveloped and developing countries benefit from the ICT revolution is to examine the contribution of ICT to economic growth, which is the precise aim of this study. In particular, this paper aims to investigate whether the ICT stock has had any positive effect on the long-run growth rate of underdeveloped and developing countries between 1995-2006. Figure 1 below is a descriptive representation of the question: it scatter plots the relationship between average growth rate and the ICT index in our sample data.

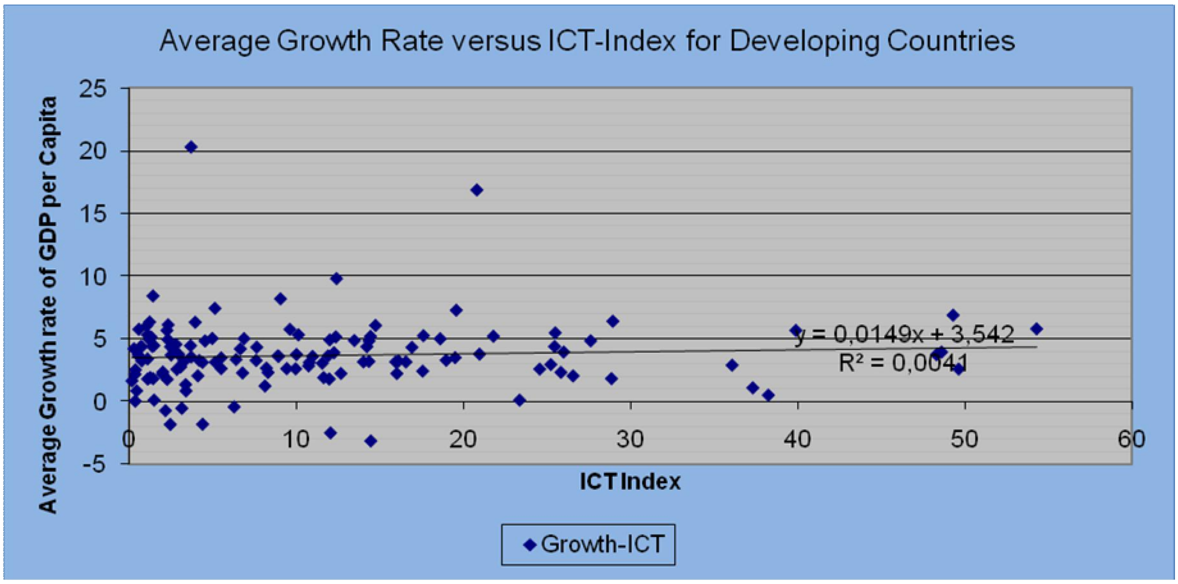

Figure 1. Average growth rate of GDP per capita versus ICT-index, 1995–2006

Figure 1 suggests that ICT investment may also be a positive determinant of long-run growth in underdeveloped and developing countries.

We believe that the answer to the question of whether ICT enhances economic growth is especially important for policy makers of developing countries. We discussed above that ICT has two channels that enhance productivity (and hence economic growth) and that many underdeveloped and developing countries are solely importers of ICT products. Policy makers of these countries may make the assumption that ICT-use is sufficient to increase productivity. The weak positive correlation illustrated in figure 1 suggests that this idea may be naïve in the sense that investment in ICT may not automatically generate higher productivity and growth. Given that these countries have limited resources, the extent that ICT-use contributes to economic growth becomes more crucial.

This study works out theoretically and econometrically whether ICT investment has a positive impact on the long-run growth performance of underdeveloped and developing countries. In the theoretical part, we augment Solow model à la Mankiw-Romer-Weil (1992), henceforth MRW (1992), and Yoo (2003) by defining ICT capital as factor of production next to from physical and human capital in the production function. We show that the expected sign of ICT investment is theoretically positive. In the empirical part of this study, we undertake a panel data analysis to assess the validity of this argument. Our panel data analysis show that the use of ICT services (generated from the ICT-index) has contributed positively to the long-run growth performance of underdeveloped and developing countries. This finding is also supported by studies such as Hardy (1980), Norton (1992), Avgerou (1998), Röller and Waverman (2001), Bassani and Scarpetta (2002) and Yoo (2003), all of which have shown the positive impact of ICT investment on economic growth.[5]

The organization of the paper is as follows. Section 2 portrays an illustrative theoretical framework. We borrow the framework from Yoo (2003). Our contribution in this part is to extend his work and to suggest some modifications. We show that ICT investment has a positive effect on economic growth for a model economy. Section 3 first describes the data, its limitations, and the panel data model. Next, the findings of the model and its implications are presented. The last section provides some concluding remarks and discusses policy implications of findings.

2. An Illustrative Framework

This study considers an augmented Solow model, à la MRW (1992). We suppose, as Yoo (2003), that there are three types of capital, namely physical capital, $K(t)$, human capital, $H(t)$, and ICT capital, $Z(t)$. The production technology is a constant-returns-to-scale Cobb-Douglas in the form of

$$Y = K^{\alpha} H^{\beta} Z^{\gamma} (AL)^{1-\alpha-\beta-\gamma} \qquad 0 < \alpha, \beta, \gamma \text{ and } \alpha + \beta + \gamma < 1 \qquad (1)$$

where α, β, and γ are production elasticities of physical capital, human capital, and ICT capital, respectively. Following the literature, we assume that labor $L(t)$ and technology $A(t)$ do grow exponentially at the exogenously given rates of n and g: $L(t) = L(0)e^{nt}$ and $A(t) = A(0)e^{gt}$.

Let us assume that output per effective capita is defined as $\tilde{y} \equiv \frac{Y(t)}{A(t)L(t)}$. Similarly, we define physical capital per effective labor $\tilde{k} \equiv \frac{K(t)}{A(t)L(t)}$, human capital per effective labor $\tilde{h} \equiv \frac{H(t)}{A(t)L(t)}$ and ICT capital per effective labor $\tilde{z} \equiv \frac{Z(t)}{A(t)L(t)}$. Then, the production function in (1) becomes $\tilde{y} \equiv \tilde{k}^{\alpha} \tilde{h}^{\beta} \tilde{z}^{\gamma}$ in terms of effective capita. Under the assumption that a constant

[5] Other studies, such as Pohjola (2002), failed to show any significant relationship between ICT and economic growth.

share of output is saved and invested for each type of capital, the following accumulation functions are defined:

$$\dot{\tilde{k}} = s_K \tilde{y} - (n+\delta+g)\tilde{k} \tag{2a}$$

$$\dot{\tilde{h}} = s_H \tilde{y} - (n+\delta+g)\tilde{h} \tag{2b}$$

$$\dot{\tilde{z}} = s_Z \tilde{y} - (n+\delta+g)\tilde{z} \tag{2c}$$

where s_K, s_H, and s_Z represent constant saving rates for physical capital, human capital, and ICT capital accumulation, respectively. For matter of tractability of the model, we assume that the depreciation rates for each type of capital are same.

It can be easily demonstrated that the differential equation system defined in (2) will not generate endogenous growth at the transitional period or at the steady state and $\tilde{k}$, $\tilde{h}$, and $\tilde{z}$ will have the following steady state values:[6]

$$\tilde{k}^* = \left[\frac{s_K^{1-\beta-\gamma} s_H^{\beta} s_Z^{\gamma}}{n+\delta+g}\right]^{\frac{1}{1-\alpha-\beta-\gamma}} \tag{3a}$$

$$\tilde{h}^* = \left[\frac{s_K^{\alpha} s_H^{1-\alpha-\gamma} s_Z^{\gamma}}{n+\delta+g}\right]^{\frac{1}{1-\alpha-\beta-\gamma}} \tag{3b}$$

$$\tilde{z}^* = \left[\frac{s_K^{\alpha} s_H^{\beta} s_Z^{1-\alpha-\beta}}{n+\delta+g}\right]^{\frac{1}{1-\alpha-\beta-\gamma}} \tag{3c}$$

By substituting respective values of $\tilde{k}^*$, $\tilde{h}^*$, and $\tilde{z}^*$ in equation (1), we find the respective steady state value of $\tilde{y}^*$:

$$\tilde{y}^* = \left[\frac{s_K^{\alpha}}{(n+\delta+g)^{\alpha}} \frac{s_H^{\beta}}{(n+\delta+g)^{\beta}} \frac{s_Z^{\gamma}}{(n+\delta+g)^{\gamma}}\right]^{\frac{1}{1-\alpha-\beta-\gamma}} \tag{4}$$

Via taking natural log of equation (4), we can show that

$$\ln \tilde{y}^* = \frac{\alpha}{1-\alpha-\beta-\gamma}\left[\ln s_K - \ln(n+\delta+g)\right] + \frac{\beta}{1-\alpha-\beta-\gamma}\left[\ln s_H - \ln(n+\delta+g)\right] + \frac{\gamma}{1-\alpha-\beta-\gamma}\left[\ln s_Z - \ln(n+\delta+g)\right] \tag{5}$$

[6] Yoo (2003) defines the solution procedure as “substituting the production function (1) in the differential equations (2), taking logarithms, and solving the resulting linear system”. This procedure cannot give the solution he presented in equation (3) in his paper. Firstly, “taking logarithms of equations in (2)” does not lead to a solution. Secondly, “taking logarithms of equations in (2)” does not yield a linear system. The true procedure is as follows. Firstly, we express equation (2) in growth rates by dividing both sides by the respective capital. Next, we jump to steady state. Third, we take time derivatives of both sides of differential equations and recall that all variables grow at constant rates at steady state. Fourth, we prove that variables do not grow at steady state. Finally, using the information that variables do not grow at steady state, we solve the 3-equation non-linear system and find respective steady state values of the three types of capital.

This is equation (3) in Yoo (2003). However, in contrast to Yoo (2003), we argue that this is not the ultimate form of the equation that should be regressed.[7] Visibly, the variable on the left hand side is output per effective labor, which is immeasurable. In that respect, we need to transform it into output per capita. Using the definition, we get

$$\ln y^* = \ln A(0) + g\cdot t + \frac{\alpha}{1-\alpha-\beta-\gamma}\ln s_K + \frac{\beta}{1-\alpha-\beta-\gamma}\ln s_H + \frac{\gamma}{1-\alpha-\beta-\gamma}\ln s_Z - \frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}\ln(n+\delta+g) \qquad (6)$$

where $y \equiv \frac{Y(t)}{L(t)}$ is output per capita and y^* is the steady state (long-run equilibrium) value of the same variable. This is one of the equations that inspired us in the empirical part of our analysis, à la MRW (1992). The model-economy shows that investment in ICT has a positive impact on real income per capita.

The Speed of Convergence in the Augmented Solow Model

Equation (6) alone may not be sufficient to capture the impact of ICT on economic growth in developing countries. What is measured in (6) is the contribution of ICT on economic growth at steady state. However, ICT is also important on economic growth in the transition to steady state. In particular, it is interesting to find out whether ICT plays any significant role in convergence of developing countries and this extension is missing in Yoo (2003). Below, we drive the convergence equation of ICT-augmented Solow model.

Recall that the production function becomes $\tilde{y} = \tilde{k}^{\alpha}\tilde{h}^{\beta}\tilde{z}^{\gamma}$ in efficiency units. Then the growth rate in income per efficiency units of labor is given by $\hat{\tilde{y}} = \alpha\hat{\tilde{k}} + \beta\hat{\tilde{h}} + \gamma\hat{\tilde{z}}$, where a hat on top of a variable denotes growth rate, i.e., $\hat{\tilde{x}} = \frac{\dot{\tilde{x}}}{\tilde{x}}$ for a variable $\tilde{x}$. Expressing the three-equation differential system in (2) in growth terms and then substituting $\hat{\tilde{y}} = \alpha\hat{\tilde{k}} + \beta\hat{\tilde{h}} + \gamma\hat{\tilde{z}}$ yields:

$$\hat{\tilde{k}} = s_K \tilde{k}^{\alpha-1}\tilde{h}^{\beta}\tilde{z}^{\gamma} - (n+\delta+g) \qquad (7a)$$
$$\hat{\tilde{h}} = s_H \tilde{k}^{\alpha}\tilde{h}^{\beta-1}\tilde{z}^{\gamma} - (n+\delta+g) \qquad (7b)$$
$$\hat{\tilde{z}} = s_Z \tilde{k}^{\alpha}\tilde{h}^{\beta}\tilde{z}^{\gamma-1} - (n+\delta+g) \qquad (7c)$$

Log-linearizing the differential equation system in (7) yields

$$\hat{\tilde{y}} \approx -(1-\alpha-\beta-\gamma)(n+\delta+g)\left[\alpha\left(\ln\tilde{k} - \ln\tilde{k}^*\right) + \beta\left(\ln\tilde{h} - \ln\tilde{h}^*\right) + \gamma\left(\ln\tilde{z} - \ln\tilde{z}^*\right)\right] \quad (8)$$

[7] Yoo (2003) mis-named variables by calling $\frac{Y(t)}{A(t)L(t)}$ as output per capita and $\frac{X(t)}{A(t)L(t)}$ as capital per capita, for $X = K, H, Z$. Perhaps this was the reason why he disregard transforming per efficient units into per capita and hence missed the opportunity of presenting the ultimate form of solution.

where a superscript star again indicates steady state value of the respective variable. Note that the growth rate in income per efficiency units involves $\ln\tilde{y} = \alpha\ln\tilde{k} + \beta\ln\tilde{h} + \gamma\ln\tilde{z}$. Hence, $\ln\tilde{y} - \ln\tilde{y}^* = \alpha\left[\ln\tilde{k} - \ln\tilde{k}^*\right] + \beta\left[\ln\tilde{h} - \ln\tilde{h}^*\right] + \gamma\left[\ln\tilde{z} - \ln\tilde{z}^*\right]$. Using this result in (8) yields

$$\hat{\tilde{y}} \approx -\lambda\left[\ln\tilde{y} - \ln\tilde{y}^*\right] \tag{9}$$

where $\lambda = (1-\alpha-\beta-\gamma)(n+\delta+g)$. Consequently, the rate of convergence is $\frac{\partial\hat{\tilde{y}}}{\partial\ln\tilde{y}} = -\lambda$. Equation (9) is a differential equation and its solution yields $\ln\tilde{y}(t) = e^{-\lambda t}\ln\tilde{y}(0) + (1-e^{-\lambda t})\ln\tilde{y}^*$. Subtracting $\ln\tilde{y}(0)$ from both sides gives

$$\ln\tilde{y}(t) - \ln\tilde{y}(0) = -(1-e^{-\lambda t})\ln\tilde{y}(0) + (1-e^{-\lambda t})\ln\tilde{y}^* \tag{10}$$

Substituting the respective value of $\tilde{y}^*$ from (4) and recalling that $\tilde{y}(t)\cdot A(t) = y(t)$ gives

$$\ln y(t) - \ln y(0) = \left(1-e^{-\lambda t}\right)\ln A(0) + g\cdot t - \left(1-e^{-\lambda t}\right)\ln y(0)$$
$$+(1-e^{-\lambda t})\left[\frac{\alpha}{1-\alpha-\beta-\gamma}\ln s_K + \frac{\beta}{1-\alpha-\beta-\gamma}\ln s_H + \frac{\gamma}{1-\alpha-\beta-\gamma}\ln s_Z - \frac{\alpha+\beta+\gamma}{1-\alpha-\beta-\gamma}\ln(n+\delta+g)\right] \tag{11}$$

This is the second equation that one may use to measure the impact of ICT on economic growth. Equation (11) suggests that growth of income is a function of the determinants of the ultimate steady state and the initial level of income, $\ln y(0)$.

3. Data, Method and Results

3.1. Data

For operational and analytical purposes, we used the World Bank classification, which uses Gross National Income (GNI) per capita as the main criterion for classifying economies. Every economy is classed as either low, middle (subdivided into lower and upper middle), or high income by the World Bank, based on GNI per capita. According to 2007 GNI per capita, the groups are: low income, $935 or less; lower middle income, $936 - $3,705; upper middle income, $3,706 - $11,455; and high income, $11,456 or more. We considered low income and middle income countries of the World Bank classification as underdeveloped and developing countries in our study (the list of countries is given in Annex A).

ICT investment data have been retrieved from World Development Indicators Online Database and is composed of members of fixed line and mobile phone subscribers per 100 people and internet users per 100 people. We are aware of the fact that these two statistics alone cannot to any extent be considered satisfactory in representing the ICT stock. However, there are serious data availability problems for underdeveloped and developing countries and we are forced to use these limited data. We also retrieved growth rates of per capita GDP, human capital, and high technology exports data directly from WDI Online. Our data set consists of 131 underdeveloped and developing countries for the period of 1995 – 2006. It is unbalanced data set because of lack of some data in series, especially for underdeveloped countries.

The economic growth rate is the dependent variable in our model, which is expressed by annual growth rate of GDP per capita. High technology exports (HIGHEXP), the percentage share of the value of high technology exports in manufactured exports, is one of the independent variables used in the empirical analysis to capture the impact of ICT on economic growth indirectly under the assumption that exports of high technology indicate the level of ICT embedded in the production. Another independent variable is ICT stock, the value of which is calculated by the number of fixed line and mobile phone number of subscribers per 100 people and Internet users per 100 people. We are aware of the fact that our definition of ICT can only be considered a first approximation. Given the limited availability of data especially for underdeveloped countries, we are forced to define ICT in this way. We also used one-year lagged value of GDP as independent variable under the expectation that previous GDP is a significant determinant of current GDP. As a proxy for human capital variable, we employed primary school completion rate (PSCR) from the WDI database. Even though there are more suitable candidates such as UNDP data on combined gross enrolment ratio for primary, secondary and tertiary education or UNDP education index, the use of these proxies causes a considerable fall in degrees of freedom because of the lack of availability of data for many of the underdeveloped countries in the data set.

3.2. Panel Data Analysis

Panel data analysis has become more popular among researchers due to its advantages. The description of panel data comes from surveys of individuals. In this context, a "panel" is a group of individuals surveyed over time repeatedly (Frees, 2004). Panel data sets have several advantages over cross-section and time-series data sets, such as providing multiple observations on each individual in the relevant sample. It usually gives a wide range of data points to the researchers by increasing the degrees of freedom and reducing the collinearity among explanatory variables. Consequently, it improves the efficiency of econometric estimates. Moreover, panel data analysis allows researchers to analyze important questions that may be overlooked in cases of using cross-sectional or time–series data sets (Hsiao, 2002).

3.3. Econometric Analysis

Several studies[8] found that the economic relationships are dynamic and using panel data techniques is the best method of conceptualizing the dynamics of adjustment.[9] For our case, it is an unquestionable fact that current growth of GDP is a function of previous growth rates. Therefore, existence of such a situation permits us to utilize the dynamic panel data model. Moreover, the inclusion of lagged independent variable makes the OLS estimator both biased and inconsistent. Arellano and Bond (1991) proposed an efficient generalized method of moment (GMM) estimator (see Arellano (2003) for a summary of further developments in the method of GMM). Thus, this discussion in the literature led us to select GMM estimation method as the most suitable. Furthermore, the result of Hausman test (that is provided below) rules out the possibility of using fixed effects estimators. Further, we specify the weighting scheme, providing for additional efficiency of GMM estimation, under the assumption of 2SLS instrument weighting matrix (Arellano, 2003). For this reason we utilized the lagged values of independent variables as instruments. Before beginning to any econometric estimation, it is important to test the reliability of series in order to get consistent results. Consequently, first of all, we carried out unit root tests of variables, which revealed that both

[8] Please refer to several studies cited in Baltagi (2008).
[9] For a wider discussion on dynamic panel data models see Baltagi (2008) and Arellano (2003).

ICT and human capital variables suffer from the unit root problem. This problem was solved by taking the first difference of the series. Further tests show us that both variables are integrated at order one (unit root test results are available from the authors on request).

Secondly, the Hausman specification test of correlated effects was applied in order to test random effects against fixed effects. According to Hausman specification test of correlated effects shown below, our model would be random effects model.

Table 1 Correlated Random Effects: Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	**1.475847**	**3**	**0.6879**

After determining the true type of the model, the dynamic panel data estimation with GMM is carried out for three alternative models. The results are shown below.

Table 2 Dynamic Panel Data Estimation Results

Variable	Model (1)	Model (2)	Model (3)
Δ(ICT)	**0.108***	**0.103***	**0.048**
	(2.076)	(1.992)	(0.744)
HIGHEXP	**-0.010**	**-0.012**	
	(-0.987)	(-1.233)	
GDP_{t-1}	**0.654****	**0.636****	**0.816****
	(8.116)	(8.171)	(14.409)
Δ(PSCR)	**0.198**		**0.004**
	(0.812)		(0.005)
CONSTANT	**1.130***	**1.406****	**0.748**
	(2.362)	(4.070)	(0.909)
Total Observations	**855**	**863**	**1122**
Adj. R^2	**0.101**	**0.152**	**0.034**

Note: t values are in parentheses.
* significant at the 10% level; ** significant at the 5% level;
*** significant at the 1% level

According to our results, ICT investment has a positive and significant impact on the growth rate of underdeveloped and developing countries in models 1 and 2. In particular, we find that one unit increase in ICT usage leads to about 0.1 percentage rise in GDP growth. Yoo (2003) had previously found the value of the coefficient of investment in ICT to be 0.553, which, we believe, is somewhat excessive. Our results indicate a negative and insignificant HIGHEXP. Recall that we used this variable an alternative measure of ICT on economic growth under the assumption that ICT is embodied in high-technology exports. The only explanation we have for this discrepancy is data problem that these countries have. The positive relation between GDP growth and its lagged value is also consistent with the literature. We find positive but insignificant impact of human capital on economic growth. All in all, we show that ICT has a positive and significant impact on economic growth. The main obstacle in researching an economic question for underdeveloped and developing country is the problem of obtaining reliable data. Unfortunately, this study is not an exception to this general rule, and any consideration of our results must also take into account this limitation.

4. Concluding Remarks

The positive impact of ICT investment on economic growth has not been sufficiently studied for underdeveloped and developing countries in the literature. In this study, we run three models to test whether ICT investment has a positive impact on economic growth. The results are important for policy makers because in the case of the impact of ICT use having a significant and positive element of economic growth, underdeveloped and developing countries should reserve resources for ICT to achieve sustainable growth. Our results show that this is, in fact, the case: ICT has a positive impact on economic growth. We therefore suggest policy makers that they should continue to invest in ICT.

Nonetheless some reservation is needed when interpreting the results, due to serious data limitations. Our ICT definition depends on data availability. As we discussed at the very beginning, ICT is rather a general-purpose technology with a very high level of pervasiveness. Data restrictions did not allow us to define a better ICT. The proxy for human capital we are forced to use also has serious limitations. Similar problems exist for human capital and even for the share of high-tech exports. Future research must focus on compiling better data for the same analysis.

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Annex A

1	Albania	South Asia	Low income
2	Algeria	Sub-Saharan Africa	Low income
3	Angola	Sub-Saharan Africa	Low income
4	Antigua and Barbuda	Latin America&Caribbean	Low income
5	Argentina	East Asia & Pacific	Low income
6	Armenia	Sub-Saharan Africa	Low income
7	Azerbaijan	Sub-Saharan Africa	Low income
8	Bangladesh	Sub-Saharan Africa	Low income
9	Barbados	Latin America&Caribbean	Low income
10	Belize	Sub-Saharan Africa	Low income
11	Benin	Sub-Saharan Africa	Low income
12	Bhutan	Sub-Saharan Africa	Low income
13	Bolivia	Sub-Saharan Africa	Low income
14	Bosnia and Herzegovina	Sub-Saharan Africa	Low income
15	Botswana	Sub-Saharan Africa	Low income
16	Brazil	Sub-Saharan Africa	Low income
17	Burkina Faso	Sub-Saharan Africa	Low income
18	Burundi	East Asia & Pacific	Low income
19	Cambodia	Europe & Central Asia	Low income
20	Cameroon	East Asia & Pacific	Low income
21	Cape Verde	Sub-Saharan Africa	Low income
22	Central African Republic	Sub-Saharan Africa	Low income
23	Chad	Sub-Saharan Africa	Low income
24	Chile	Sub-Saharan Africa	Low income
25	China	Sub-Saharan Africa	Low income
26	Colombia	Sub-Saharan Africa	Low income
27	Comoros	East Asia & Pacific	Low income
28	Congo, Rep.	Sub-Saharan Africa	Low income
29	Costa Rica	Sub-Saharan Africa	Low income
30	Côte d'Ivoire	South Asia	Low income
31	Croatia	East Asia & Pacific	Low income
32	Djibouti	Sub-Saharan Africa	Low income
33	Dominica	Sub-Saharan Africa	Low income
34	Dominican Republic	Sub-Saharan Africa	Low income
35	Ecuador	East Asia & Pacific	Low income
36	Egypt, Arab Rep.	Sub-Saharan Africa	Low income
37	El Salvador	Europe & Central Asia	Low income
38	Equatorial Guinea	Central Africa	Low income
39	Eritrea	Sub-Saharan Africa	Low income
40	Ethiopia	Sub-Saharan Africa	Low income
41	Fiji	Sub-Saharan Africa	Low income
42	French Polynesia	Pacific	Low income
43	Gabon	Europe & Central Asia	Low income
44	Gambia, The	East Asia & Pacific	Low income
45	Georgia	Middle East & North Africa	Low income
46	Ghana	Sub-Saharan Africa	Low income
47	Grenada	Sub-Saharan Africa	Low income
48	Guatemala	Europe & Central Asia	Lower middle income
49	Guinea	Middle East & North Africa	Lower middle income
50	Guinea-Bissau	Sub-Saharan Africa	Lower middle income
51	Guyana	Europe & Central Asia	Lower middle income
52	Haiti	Europe & Central Asia	Lower middle income
53	Honduras	South Asia	Lower middle income
54	India	Latin America & Caribbean	Lower middle income
55	Indonesia	Europe & Central Asia	Lower middle income
56	Iran, Islamic Rep.	Sub-Saharan Africa	Lower middle income

57	Jamaica	East Asia & Pacific	Lower middle income
58	Jordan	Latin America & Caribbean	Lower middle income
59	Kazakhstan	Sub-Saharan Africa	Lower middle income
60	Kenya	Middle East & North Africa	Lower middle income
61	Kiribati	Latin America & Caribbean	Lower middle income
62	Korea, Dem. Rep.	Latin America & Caribbean	Lower middle income
63	Kyrgyz Republic	Middle East & North Africa	Lower middle income
64	Lebanon	Latin America & Caribbean	Lower middle income
65	Lesotho	Latin America & Caribbean	Lower middle income
66	Liberia	Latin America & Caribbean	Lower middle income
67	Libya	South Asia	Lower middle income
68	Macao China	Asia	Lower middle income
69	Macedonia, FYR	Middle East & North Africa	Lower middle income
70	Malawi	Middle East & North Africa	Lower middle income
71	Malaysia	East Asia & Pacific	Lower middle income
72	Maldives	Sub-Saharan Africa	Lower middle income
73	Mali	Europe & Central Asia	Lower middle income
74	Mayotte	Indian Ocean	Lower income
75	Marshall Islands	South Asia	Lower middle income
76	Mauritania	East Asia & Pacific	Lower middle income
77	Mauritius	East Asia & Pacific	Lower middle income
78	Mexico	East Asia & Pacific	Lower middle income
79	Micronesia, Fed. Sts.	Middle East & North Africa	Lower middle income
80	Moldova	Sub-Saharan Africa	Lower middle income
81	Mongolia	Latin America & Caribbean	Lower middle income
82	Morocco	Latin America & Caribbean	Lower middle income
83	Mozambique	East Asia & Pacific	Lower middle income
84	Namibia	South Asia	Lower middle income
85	Nepal	Sub-Saharan Africa	Lower middle income
86	New Caledonia	Southwest Pacific	Lower middle income
87	Nicaragua	Sub-Saharan Africa	Lower middle income
88	Niger	Middle East & North Africa	Lower middle income
89	Nigeria	East Asia & Pacific	Lower middle income
90	Oman	Arabia	Lower middle income
91	Pakistan	East Asia & Pacific	Lower middle income
92	Panama	Middle East & North Africa	Lower middle income
93	Papua New Guinea	Europe & Central Asia	Lower middle income
94	Paraguay	Europe & Central Asia	Lower middle income
95	Peru	East Asia & Pacific	Lower middle income
96	Philippines	Middle East & North Africa	Lower middle income
97	Rwanda	Latin America & Caribbean	Upper middle income
98	Samoa	Sub-Saharan Africa	Upper middle income
99	Saudi Arabia	Arabia	Upper middle income
100	Senegal	Europe & Central Asia	Upper middle income
101	Seychelles	Latin America & Caribbean	Upper middle income
102	Sierra Leone	Europe & Central Asia	Upper middle income
103	Slovenia	Europe	Upper middle income
104	Solomon Islands	Latin America & Caribbean	Upper middle income
105	Sri Lanka	Sub-Saharan Africa	Upper middle income
106	St. Kitts and Nevis	Latin America & Caribbean	Upper middle income
107	St. Lucia	Latin America & Caribbean	Upper middle income
108	St. Vincent and the Grenadines	Europe & Central Asia	Upper middle income
109	Sudan	Europe & Central Asia	Upper middle income
110	Suriname	Middle East & North Africa	Upper middle income
111	Swaziland	Middle East & North Africa	Upper middle income
112	Syrian Arab Republic	Europe & Central Asia	Upper middle income
113	Tajikistan	East Asia & Pacific	Upper middle income
114	Tanzania	Sub-Saharan Africa	Upper middle income
115	Thailand	Sub-Saharan Africa	Upper middle income

116	Timor - Leste	East Asia&Pacific	Lower middle income
117	Togo	Europe & Central Asia	Upper middle income
118	Tonga	East Asia & Pacific	Upper middle income
119	Trinidad and Tobago	Latin America&Caribbean	Lower middle income
120	Tunisia	Latin America & Caribbean	Upper middle income
121	Turkey	Europe & Central Asia	Upper middle income
122	Turkmenistan	Europe & Central Asia	Upper middle income
123	Uganda	Europe & Central Asia	Upper middle income
124	Uruguay	Sub-Saharan Africa	Upper middle income
125	Uzbekistan	Sub-Saharan Africa	Upper middle income
126	Vanuatu	Latin America & Caribbean	Upper middle income
127	Venezuela, RB	Latin America & Caribbean	Upper middle income
128	Vietnam	Latin America & Caribbean	Upper middle income
129	Yemen, Rep.	Europe & Central Asia	Upper middle income
130	Zambia	Latin America & Caribbean	Upper middle income
131	Zimbabwe	Latin America & Caribbean	Upper middle income

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