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ICT & Economic Growth: A Comparison Between Developed & Developing Countries

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Abstract

Information and Communication technology (ICT) plays a very important role in macroeconomics of both developed as well as developing countries. The impact of ICT usage on promotion innovation, raising productivity and increasing economic growth and therefore economic well-being of human beings are being emphasized in recent studies especially during the last decade of twentieth and the first decade of twenty first century. The purpose of this paper is to compare the impact of ICT on economic growth in developed and developing countries. To do so, we have used a sample of both countries for which the necessary data were available for the period 2001-2012. Having concentrate on the usage aspect of ICT to deal with its impact on economic growth we have used a new composite index of ICT called Digital Opportunity Index (DOI) covering 3 dimensions including overall opportunity, infrastructure and application. Our findings based on panel data regression models indicate that in general significance and positive relationship between ICT and economic growth exists in both developed and developing countries. However, our results indicated a stronger impact for the developing countries. This may be due to a relatively more recent usage of ICT in developing countries .I other words; these countries experience the early stage of using ICT as compared to developed countries. Therefore, policies to promote usage of ICT in all countries especially in developing countries are suggested.

Keywords

Digital Opportunity Index, ICT, Economic Growth, Developed Countries, Panel Data

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1. Introduction

In general, the world entered a new era from half of the 20th century. Firstly, by introducing computers to the market and combining with the field of information and communications, computers linked to the - telephone and television – and "ICT" revolution occurred. The ICT has some effects on different economic variables. In fact ICT is influential in both supply and demand sides. In demand side the consumer's economic behavior through utility function and in supply side on producer's behavior through productive function will be affected. In supply side, ICT associated with other complementary infrastructure components resulted in capital deepening, reorganization of economic processes and ultimately increasing the economic growth and productivity of productive factors in developing countries. Since in developing countries, there is not enough competitive space and the majority of market is under the government control,

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ICT effects on economic growth and productivity is observed with a little delay. However, studies in 1990s showed that increasing investment in this field constantly resulted in emergence of positive and powerful relation between economic growth and information technology were economic. This study aims to test investigated relation between economic growth and information and ICT in developing countries, at a macro level.

"The methodology of measuring the contribution of ICT to growth and productivity is based on original work by Solow (1957) and Jorgenson and Griliches (1968) and later extended by inter Alia Oliner and Sichel (2000) and Jorgenson and Stiroh (2000). Since ICT products and services are both outputs from the ICT industries and inputs into ICT-using industries, ICT can impact economic growth through four major channels (Jalava, Pohjola 2002)":

(i) Production of ICT goods and services, which directly contributes to the aggregate value added generated in an economy;

(ii) Increase in productivity of production in ICT sector, which contributes to overall productivity in an economy (TFP);

(iii) Use of ICT capital as in input in the production of other goods and services;

(iv) Contribution to economy-wide TFP from increase in productivity in non-ICT producing sectors induced by the production and use of ICT (spillover effects);

To measure the overall impact of ICT on growth, it is best to express the aggregate production function in the following form1:

$$Y_t = Y\,(Y_t^{ICT}, Y_t^{0}) = A_t\,F\,(C_t, K_t, Lt) \qquad \text{(a)}$$

Where, at any given time t, aggregate value added Y is assumed to consist of ICT goods and services ICT – Y_t^{ICT}, as well as of other production Y_t^0. These outputs are produced from aggregate inputs consisting of ICT capital C_t, other (i.e. non-ICT) physical capital K_t, and labor L_t. TFP (total factor productivity) is here represented in the Hicks neutral or output augmenting form by parameter A.

Assuming that constant returns to scale prevail in production and that all production factors are paid their marginal products, equation (a) can be expressed in the following form:

$$\hat{Y} = w_{ICT}\,\hat{Y}^{ICT} + w_0\hat{Y}^0 = v_{ICT}\,\hat{C}t + v_0\hat{K}_0 + v_L\,\hat{L} + \hat{A} \qquad \text{(b)}$$

Where symbol ^ indicates the rate of change and the time index t has been suppressed for the simplicity of exposition.

The weights w_{ICT} and w_0 denote the nominal output shares of ICT and non-ICT production, respectively. The weights sum to one similarly as the weights v_{ICT}, v_0, and v_L, which represent the nominal shares of ICT capital, non-ICT capital, and labor, respectively2.

Denoting the total employment by H(t) and labor productivity by Y(t)/H(t), the equation (b) can then be re-arranged to measure the contribution of ICT investment to growth in labor productivity

$$\hat{Y} - \hat{H} = v_{ICT}\,(\hat{C}t - \hat{H}) + v_0\,(\hat{K}_0 - \hat{H}) + \hat{A} \qquad \text{(c)}$$

As shown in the above equation, there are three sources of growth in labor productivity: ICT capital deepening, i.e. increase in ICT capital services per employed person, non-ICT capital deepening, and total factor productivity.

Due to limited scope of the paper, the paper will focus on only one channel t through which ICT impacts growth namely, through the contribution o of ICT capital output growth.

Figure (1) shows how ICT helps economic growth and productivity in supply side3.

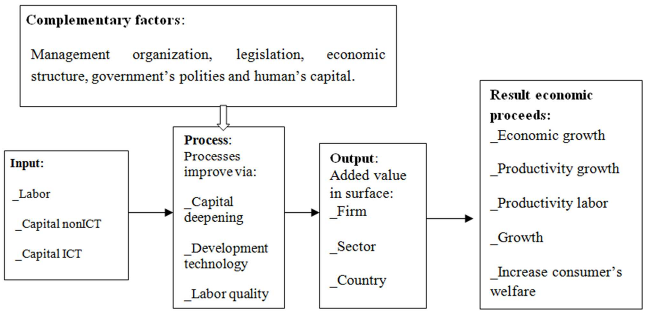

Figure (1). Channels through which ICT contributes to productivity growth

2. ICT and Economic Growth: Empirical Studies

Recently, some studies have analyzed the relationship between IT and economic performance. Many of them examined the impact of IT on productivity growth. However, the main conclusion of most studies supported the positive impact of ICT on economic performances of developed as compared to developing countries. For example, using new sect oral data on investment and capital services Mas and Quesada (2000) carried out a growth accounting exercise on Spain 1985-2002. They computed the contribution to output

1. Pohjola(2002)

2. Please note that this study does not correct TFP for changes in labor quality. Hence, given anecdotal evidence pointing to the increase in quality of human capital, the results produced in this study are likely to overestimate the true increase in TFP in Poland.

3. Dedrick et al.(2003)

and labor productivity growth of employment, non-ICT and ICT capital, labor qualification and Total Factor Productivity. Results are given for 29 different branches; individually and grouped into four clusters according to their ICT use intensity. Three ICT assets (hardware, communications and software) are considered. They found that although the ICT intensive group appears to be the most dynamic cluster, most of the impact on productivity is still to come. Masten and Kandoole (2000) examined IT patterns of investment in Malawi. They found that the government has focused a great deal of attention on assisting small- and medium-sized enterprises (SMEs) in using IT to increase employment and income. This may be because there is no large amount of foreign direct investment by large, multinational firms in this country. Moodley (2012) conducted an in-depth quantitative and qualitative analysis of the use of B2B e-commerce by manufacturing firms in South Africa. His study is based on 120 firm level interviews and 31 interviews with industry experts. His evidence indicates that the incidence of use is fairly low. Although 87% of the firms had access to the Internet, only 49% of the firms had a corporate website and only22% was using the Internet for order taking. He concluded that e-commerce is not yet an important strategic objective for most South African firms. Hoon (2003) explored the impact of ICT investment on economic growth using a cross-country analysis based on data from 56 developing countries for the years 1970–1998 and found that ICT positively contributes to economic growth in the developing world. van Ark and Piatcovski (2004) analyzed IT investment patterns and their impact on economic performance in two sets of countries regarded as being at different levels of economic development: the 15 countries of the European Union (“old” Europe) and 10 Central European economies under accession (“new” Europe). They conclude that there is a trend toward convergence in investment in IT between “old” and “new” Europe. Investment in IT capital was also found to be an important source of productivity growth in both sets of countries. Some researchers address these difficulties by developing their own taxonomies. For example, van Ark, Frankema, and Duteweerd (2004) divided the economy into three distinct sectors: IT producing industries, IT using industries, and non-IT industries. The second and third categories are defined on the basis of their “IT intensity,” or IT capital per worker or per unit of output. Interestingly, they found that non-IT industries constitute two thirds of the US and European economies, and an even higher fraction in emerging economies. Indjikian and Siegel (2005) reviewed quantitative and qualitative research on the impact of IT on economic performance in developed and developing countries. In general, studies from the developed world have yielded evidence of a strong positive correlation between IT and economic performance, as well as IT-induced changes in workforce composition in favor of highly skilled or educated workers and organizational changes that allow firms to implement IT more effectively. Using the new data from after 1995, Jorgenson and Vu (2005) found that the contribution of ICT capital to world GDP had more than doubled and now accounts for 0.53 per cent of the world average GDP growth of3.45 per cent. The percentage was higher for the group of G7 countries, where ICT investments contributed with 0.69 per cent to a GDP growth of 2.56 per cent during 1995–2003. Oulton and Srinivasan (2005) used a new industry-level dataset to quantify the role of ICT in explaining productivity growth in the UK, 1970-2000. The dataset is for 34 industries covering the whole economy (31 in the market sector). Using growth accounting they found that ICT capital played an increasingly important, and in the 1990s the dominant, role in accounting for labor productivity growth in the market sector. Econometric evidence also supports an important role for ICT. They also found econometric evidence that a boom in complementary investment in the1990s could have led to a decline in the conventional measure of TFP growth. Ketteni (2006) has shown that total ICT capital has a nonlinear effect on total factor productivity growth. Jalava and Pohjola (2007) analyzed the impacts of information and communications technology on output and labour productivity growth in Finland in 1995–2005. Information and communications technology (ICT) accounted for 1.87 percentage points of the observed labour productivity growth at the average rate of 2.87 per cent. The contribution from increases in ICT capital intensity was 0.46 percentage points. The rest is attributed to multi-factor productivity growth in ICT production, especially in telecommunications production. The ongoing outsourcing of ICT production to low-wage countries provides a threat to productivity performance in the future. Policy makers should consider where the next wave of productivity growth will come from. Youngsang Cho, Jongsu Lee and Tai-Yoo Kim (2007) investigated the effects of information and communications technology (ICT) investment, electricity price, and oil price on the consumption of electricity in South Korea’s industries using a logistic growth model. They found that ICT investment reduces electricity consumption in only one manufacturing sector and that it increases electricity consumption in other five sectors including service sector in South Korea. Ketteni and cooperators (2007) has examined the Information and Communication Technology (ICT) capital-economic growth nexus, taking into consideration the previously documented nonlinear relationship between initial income and human capital on the one hand and economic growth on the other. They applied nonparametric techniques for a number of OECD countries for the period 1980–2004. Kweku and Bryson (2008) have examined the effects of the interaction between ICT and labor force on economic growth in transition economies. In this study, they investigate the presence of complementarily between investments in Telecoms and full-time Telecom staff in the context of transition economies (TE). Using translog formulation of Cobb–Douglas production function, they determined the presence of statistically significant interaction effect between the two variables. The direction of the effect, however, varies between the two subgroups of TEs in their sample, thus suggesting the presence of the level-dependent threshold. JooSeo, SooLee and Hun Oh (2009) build a model of cumulative growth to examine the dynamic interdependent relationship between Information and Communication Technology (ICT) investment and economic growth for a sample of 29 countries in the 1990s. They confirm the following facts: First, there is a positive correlation between ICT investment and economic growth. Second, non-ICT investment has as much influence on the growth gap as ICT investment. Third, those countries with a solid economic infrastructure and open trade regime experience more active ICT investments. Fourth, those countries with a comparatively lower productivity level can reduce the gap using knowledge spillovers from more advanced countries. Fifth, reinforcement of patent rights has a positive influence on economic growth by stimulating the accumulation of ICT capital. Finally, ICT investment does not have a strong interdependent relationship with economic growth, while non-ICT investment has a cumulative causal relationship with economic growth and plays a key role in the process of widening the growth gap. Koutroumpis (2009) thematic investigates how broadband penetration affects economic growth. A macroeconomic production function with a micro-model for broadband investment is used to estimate the impact of broadband infrastructure and growth. The results indicate a significant causal positive link especially when a critical mass of infrastructure is present. The scope of this research is 22 OECD countries based on data collected for the period 2002–2007. Rim Ben Ayed Mouelhi (2009) aimed at measuring the impact of information and communication technology use on the efficiency of the Tunisian manufacturing sector at the firm level within a simple theoretical framework. They used a firm-level panel data for the manufacturing sector in Tunisia to investigate whether adoption of ICT influences efficiency in factor use. The analysis is conducted through the use of a parametric method to measure technical efficiency. They estimated a stochastic production frontier and the relationship aims to explained technical efficiency differentials in a single stage as suggested by Battese and Coelli [Battesse, G.E, Coelli, T.J. (1995). A model for technical inefficiency in a stochastic frontier production functions for panel data. Empirical Economics, 20, 325–332].

3. Model, Data, and Estimation Methodology

The purpose of this paper is to compare the impact of ICT on economic growth in developed and developing countries. To do so, we have used a sample of 60 developed & developing countries for which the necessary data were available for the period 2001-2012. This time period and frequency is largely dictated by the availability of data on DOI. Data on DOI, GDP, 4 Investment (Gross fixed capital formation), labor force in constant (2000 US $) prices, Exports of goods and services (% of GDP) and General government final consumption expenditure (% of GDP) are from WDI,5 and ITU.6

We have also used a new composite index of ICT called Digital Opportunity Index (DOI). The Digital Opportunity Index is an e-index based on internationally-agreed ICT indicators. This makes it a valuable tool for benchmarking the most important indicators for measuring the Information Society. The DOI is a standard tool that governments, operators, development agencies, researchers and others can use to measure the digital divide and compare ICT performance within and across countries. The Digital Opportunity Index (DOI) is based on 11 ICT indicators, grouped in 3 clusters: opportunity, infrastructure and utilization.

The basic model to be estimated on panel data for 30 developing countries is a simple Cobb-Douglas production function and the sample period is 2001-2012.

$$GDP_{it} = Exp\ (\alpha_i + \beta 1 DOI) + (Ex_{it}/GDPit)^{\beta 2} + (G_{it}/GDP_{it})^{\beta 3} L_{it}^{\beta 4} K_{it}^{\beta 5} \quad (1)$$

The variables (for country i and time t):

GDP is gross domestic production.

L is labor force.

K is gross fixed capital formation.

DOI is digital opportunity index.

(Ex/GDP_{it}) is Exports of goods and services (% of GDP).

(G/GDP) is General government final consumption expenditure (% of GDP).

The model can be rewritten as follows:

$$Ln\ (GDP_{it)}) = \alpha_i + \beta_1 DOI + \beta_2 Ln\ (Ex_{it}/GDP_{it}) + \beta_3 Ln\ (G_{it}/GDP_{it}) + \beta_4 Ln(L_{it}) + \beta_5 Ln(Kit) + €_{it} \quad (2)$$

4. Gross Domestic Product
5. World Development Indicator
8. International Télécommunication Union (ITU).

In order to compare the impact of ICT on economic growth of developed & developing countries we will use a dummy variable as follows:

$$Ln(GDP_{it})=\alpha_i+\beta_1 Ln(K_{it})+\beta_2 Ln(L_{it})+\beta_3 Ln(G_{it}/GDP_{it})+\beta_4 Ln(Ex_{it}/GDP_{it})+\beta_5 DOI+\beta 6DVDOI+\varepsilon_{it} \quad (3)$$

DV=1 for developing countries

DV=0 for developed countries

We estimate the model using panel datamethod.

In general a regression model of panel data is as follow:

$$Y_{it}=\alpha_{it}+\beta_1 X_{1it}+\beta_2 X_{2it}+\ldots+U_{it} \quad U_i=\mu_i+\nu_{it} \quad (4)$$

Where $E(U_i)=0$ and have constant variance. μ_i include fixed effects that show difference between individual, households or countries especial characteristic.

ν_{it} is residual term that:

$$\nu_{it} \approx IND(0,\delta_7^4) \quad (5)$$

First we test heterogeneous between units by F-statistic. If null hypothesis isn't accepted, we use panel data. Null hypothesis is:

$$H_0 : \mu_1 = \mu_2 = \ldots = \mu_N = 0$$
$$H_1 \neq H_0$$

$$F = \frac{(RRSS-URSS)/(N-1)}{URSS/(NT-N-K)} \sim F_{[(N-1),(NT-N-K)]} \quad (6)$$

RRSS: Restrict Residual sum Squares

URSS: Unrestricted Residual sum Squares

N=numbers of units

K=numbers of parameters

Then for choice between Fixed Effect (F.E) and Random Effect (R.E) models we used Hausman Test:

$$H=(b_s-\beta_s)'(M_1-M_0)^{-1}(b_s-\beta_s) \approx \chi^2(r) \quad (7)$$

Where $r=$ numbers of parameters, $M_1=$covariance matrix for coefficients of F.E model (b_s), $M_0=$ covariance matrix for coefficients of R.E model (β_s)

In Hausman test null hypothesis show Fixed Effect. In according above tests we run the regression using Random effect model (EGLS7 method). Table 1 and table 2 presents the pool EGLS (cross-section weights) regression results with and without dummy variable respectively.

Table 1. Estimation results without Dummy Variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.51846	0.66808	17.24097	0.0000
Ln(L)	0.813742	0.04454	18.26884	0.0000
Ln(k)	0.185639	0.01359	13.65717	0.0000
Ln(G/GDP)	0.000626	0.00238	0.262648	0.7930
(EX/GDP)	0.001458	6.11E-05	23.85852	0.0000
DOI	0.711944	0.02689	26.47598	0.0000
		Effects Specification Weighted Statistics		
R-squared	0.999871	Mean dependent var		48.68078
Adjusted R-squared	0.999841	S.D. dependent var		40.83451
S.E. of regression	0.039952	Sum squared resid		0.474068
F-statistic	95107.10	Durbin-Watson stat		1.106518
Prob(F-statistic)	0.000000			
		Unweighted Statistics		
R-squared	0.999606	Mean dependent var		25.43504
Sum squared resid	0.517268	Durbin-Watson stat		0.797206

Dependent Variable: Ln(GDP)
Method: Pooled EGLS (Cross-section weights)
Sample: 2001- 2012
Included observations: 6
Cross-sections included: 61
Total pool (balanced) observations: 363

Table 2. Estimation results with Dummy Variable

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	15.02764	0.745629	20.15431	0.0000
Ln(L)	0.591018	0.049000	12.06155	0.0000
Ln(k)	0.179498	0.007875	22.79455	0.0000
Ln(G/GDP)	0.001151	0.000242	4.752152	0.0000
(EX/GDP)	0.001442	0.000156	9.227073	0.0000
DOI	0.513643	0.028130	18.25969	0.0000
DVDOI	0.674341	0.024408	27.62827	0.0000
		Effects Specification Weighted Statistics		
R-squared	0.999837	Mean dependent var		47.47075
Adjusted R-squared	0.999823	S.D. dependent var		29.44385
S.E. of regression	0.036491	Sum squared resid		0.394157
F-statistic	71584.99	Durbin-Watson stat		1.183276
Prob(F-	0.000000			

7. Generalize Least Squares (GLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
statistic)				
		Unweighted Statistics		
R-squared	0.999679	Mean dependent var		25.43504
Sum squared resid	0.421471	Durbin-Watson stat		0.963705

Dependent Variable: Ln(GDP)
Method: Pooled EGLS (Cross-section weights)
Sample: 2001 2012
Included observations: 6
Cross-sections included: 61
Total pool (balanced) observations: 363

4. Findings and Concluding Remarks

Based on regression results in table 1 the estimated parameters -except coefficient of DOI- in equation (2) is positive and significance. The elasticity's of labor and gross fixed capital formation are positive and significant. The impact of Exports of goods and services (% of GDP) on economic growth is positive and significance. The elasticity's General government final consumption expenditure (% of GDP) is positive and insignificant. The other words 1 unit increase in DOI and Exports of goods and services increases economic growth about %0.71 and %0.001458. 1% increase in labor, investment and General government final consumption expenditure increases economic growth about %0.81, %0.18 and %0.000626.

In general a positive relationship between ICT and economic growth exists but it is significance at 15 percent level in the countries under consideration. Therefore, new developments in ICT in those countries are suggested.

Our findings show that because of invested heavily in new ICT during the past decade and, as a result, they are also very likely to experience the spread of the New Economy and more rapid growth during this decade in chosen countries the effect of this variable on economic growth was significance.

In order to compare the impact of ICT on economic growth of developed & developing countries we have used a dummy variable (DV) on the slope of the ICT variable in the model with the value 1 for developing countries and zero for developed countries. The estimated regression results are shown in table 2 . As shown in table 2, there is a significant difference between performance of developing countries and that of developed countries regarding the impact of ICT on economic growth In other words, the impact of DOI on economic growth in developing countries is positive and significance, with the coefficient of DOI 1.187. However, DOI coefficient for developed countries is 0.51. Therefore, the positive impact of ICT on economic growth in developing courtiers is greater than developed countries. These results support Mansl (2000),regarding the notion that information and communication technology for sustainable development in developing countries is an essential principle

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