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ICT and Economic Growth: New Evidence from Some Developed Countries

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Abstract: There have been significant advances in the field of information and communication technology (ICT) in recent decades. ICT plays a major role in innovation, raising productivity and increasing economic growth and therefore affects all economic sectors. The purpose of this paper is to estimate the impact of ICT on economic growth in developed countries. To do so, we have used a sample of 30 developed countries for which the necessary data were available for the period 2001-2006. We concentrated on the usage aspect of ICT to deal with its impact on economic growth. We have also used a new composite index of ICT called Digital Opportunity Index (DOI) covering 3 dimensions including overall opportunity, infrastructure and applications. Our findings based on a panel data regression models indicate that in general significance and positive relationship between ICT and economic growth exists in the countries under consideration. Therefore the expansion of ICT programs in these countries is suggested.

Key words: Digital Opportunity Index; ICT; Economic Growth; Developed countries; Panel Data.

INTRODUCTION

In general, the world entered in new era from the end of the 20th century. The expansion of 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, 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 ICT in developed 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 form:

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$$Y_t = Y(Y_t^{ICT},\ Y_t^0) = A_t F(C_t\ ,\ K_t\ ,L_t) \quad (1)$$

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 (1) can be expressed in the following form:

$$\hat{Y} = w_{ICT}\ \hat{Y}^{ICT} + w_0 \hat{Y}^0 = v_{ICT}\ \hat{C}t + v_0 K\hat{\ }_0 + v_L\ L\hat{\ } + \hat{A} \quad (2)$$

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, respectively.

Denoting the total employment by H(t) and labor productivity by Y(t)/H(t), the equation (2) can then be re-arranged to measure the contribution of ICT investment to growth in labor productivity

$$\hat{Y} - \hat{H} = v_{ICT}\ (\ \hat{C}t - \hat{H}) + v_0\ (K\hat{\ }_0 - \hat{H}) + \hat{A} \quad (3)$$

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 to through which ICT impacts growth that is through the contribution o of ICT capital output 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, Lichtenberg (1995) and Lehr and Lichtenberg(1999), using estimates of Cobb–Douglas production functions, came to similar conclusions: ICT investment contributes significantly to firm output and generates high levels of returns, which are much higher than the returns of the non-ICT investment. Dewan and Min (1997), using multiple econometric models provide consistent and confirmatory evidence of a positive relation between ICT investment and firm output. Gurbaxani et al. (1998), based on data from large firms belonging to the 'Fortune 1000' between 1987 and 1994, examine the returns to different kinds of computer hardware investments; using estimates of a Cobb–Douglas production function they found that investments in mainframe and PC hardware are positively associated with firm output. 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 (2002) 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. 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. 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. 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:

We study the case of developed countries and use annual data for the 2001 - 2006 periods. This time period and frequency is largely dictated by the availability of data on DOI. Data on DOI, GDP, 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, and ITU.

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 developed countries is a simple Cobb-Douglas production function and the sample period is 2001-2006.

$$GDP_{it} = Exp\ (\alpha_i + \beta_1\ (Ex_{it}/GDPit) + \beta_2 DOI + \beta_3\ (G_{it}/GDP_{it}))\ L_{it}^{\beta 4}\ K_{it}^{\beta 5} \qquad (4)$$

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:

$$\text{Ln}\ (GDP_{it}) = \alpha_i + \beta_1\ (Ex_{it}/GDP_{it}) + \beta_2 DOI + \beta_3\ (G_{it}/GDP_{it}) + \beta_4\ \text{Ln}\ (L_{it}) + \beta_5 \text{Ln}\ (Kit) + €_{it} \quad (5)$$

We run the regression whit use of panel data technique.
In general a regression model of panel data is as follow:

$$Y_{it} = \alpha_{it} + \beta_1 X_{1it} + \beta_2 X_{2it} + ... + U_{it} \qquad U_i = \mu_i + \nu_{it} \quad (6)$$

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:

$$\nu_{it} \approx IND(0, \delta_7^4) \quad (7)$$

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

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

$$F = \frac{(RRSS - URSS)/(N-1)}{URSS/(NT - N - K)} \sim F_{[(N-1),(NT-N-K)]} \quad (8)$$

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:

Where r = numbers of parameters, $M_1 =$ covariance matrix for coefficients o f 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 whit Random effect model (EGLS method). Table 1 presents the pool EGLS (cross-section weights) regression results

Table 1:

Dependent Variable: Ln(GDP)
Method: Pooled EGLS (Cross-section weights)
Sample: 2001 2006
Included observations: 6
Cross-sections included: 30
Total pool (balanced) observations: 180

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	15.64536	1.463707	10.68886	0.0000
Ln(L)	0.591031	0.094539	6.251719	0.00000
Ln(k)	0.147769	0.028906	5.112091	0.00000
(G/GDP)	-0.011928	0.003151	-3.785193	0.0002
(EX/GDP)	0.001448	0.000274	5.295110	0.0000

DOI	0.673085	0.047909	14.04913	0.0000
		Effects Specification		
		Weighted Statistics		
R-squared	0.999916	Mean dependent var	45.21175	
Adjusted R-squared	0.999896	S.D. dependent var	26.00986	
S.E. of regression	0.032919	Sum squared resid	0.157131	
F-statistic	50641.81	Durbin-Watson stat	0.863098	
Prob(F-statistic)	0.000000			
		Unweighted Statistics		
R-squared	0.999927	Mean dependent var	25.79451	
Sum squared resid	0.183727	Durbin-Watson stat	0.524797	

4. Findings and Concluding Remark:

Based on regression results in table 1 the estimated parameters -except coefficient of DOI- in equation (5) are significant. The elasticities of labor, gross fixed capital formation, Exports of goods and services (% of GDP) are and DOI is positive and significant. The elasticity's General government final consumption expenditure (% of GDP) is negative and significant. The other words 1% increase in DOI, labor, investment and Exports of goods and services increases economic growth about %0.673085, %0.591031, %0.147769 and 0.001448. 1% increase in General government final consumption expenditure decrease economic growth about %-0.011928. In general significance positive impact exists in the countries under consideration.

This paper's 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 developed countries the effect of this variable on economic growth was significance.

Investing heavily in ICT is not, however, the only requirement to create the New Economy. Nations must also (1) restructure their economies, cut costs, improve flexibility, and make better use of technology, (2) increase the pace of deregulation, especially in telecommunication and labor markets, (3) encourage an entrepreneurial culture and make it easier to start new businesses, (4) liberalize financial markets to funnel capital to the best uses, (5) develop venture capital to finance innovative companies, and (6) adjust monetary policy to the realities of the New Economy by waiting for inflation to appear before raising interest rates.

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