Iranian Economic Review, Vol.16, No.30, Fall 2011

Information and Communication Technology Externalities and Economic Growth in Newly Industrialized Countries

Maryam Farhadi*

Ismail Rahmah**

Received: 2010/08/28 Accepted: 2011/04/24

Abstract

In recent years, progress in information and communication technology (ICT) has caused many structural changes such as reorganizing of economics, globalization, and trade extension, which leads to capital flows and enhancing information availability. Moreover, ICT plays a significant role in development of each economic sector, especially during liberalization process. Growth economists predict that economic growth is driven by investments in ICT. However, empirical studies on this issue have produced mixed results, regarding to different research methodology and geographical configuration of the study. The aim of this research is to empirically study the external effects of ICT on economic growth by the endogenous production growth model, using panel data collected from newly industrialized countries (NICs) in the world namely Mexico, Brazil, China, India, South Korea, Malaysia, Singapore, Philippines, Thailand and Turkey over the period of 1990-2008. This paper indicates a considerable lags between the time of investing in these technologies and the time at which the externalities arise. The focus is on the possible network effects and spillovers emerging as externalities from investments in ICT. This study also shows that productivity obtained from ICT is larger than one would expect from a standard neoclassical growth accounting approach.

Keywords: Economic growth, Information and Communication Technology, Externality, globalization, Newly Industrialized Countries.

---

* Islamic Azad University, Mobarakeh Branch, Department of Accounting, Isfahan (Corresponding Author).

** Professor, Faculty of Economics and Business, University of Kebangsan Malaysia.

1- Introduction

It is widely recognized that in the recent decades, the nature of the global economy has changed toward personal computers, Internet, cell phone and broadband networks. It means that, information and communication technology (ICT) has become an essential part of economy and there was an increasing trend in ICT investment in many countries across the world during the last two decades. The global ICT investment has increased from about three percent of GDP to about eight percent for the period 1992- 2006 as shown in figure 1. On the other hand, labour productivity has increased considerably in the developed and some developing countries. Despite the earlier uncertainty, many economists confirm the direct effect of ICT investment on the productivity (Jorgenson 2001; Oliner and Sichel 2002; Van Ark et al 2002; Stiroh 2002; Jorgenson and Stiroh 2000; Gordon 2000). They assert that ICT has a direct effect on capital deepening through the rapid technological progress which leads to lower quality-adjusted prices and increasing output.

However, ICT is known as a general purpose technology and its effect on productivity goes beyond the capital deepening effect (Lipsey et al 2005). Moreover, ICT is a form of knowledge and network capital with the ability to improve overall productivity across different sectors in the economy through its effects on organization, management, and human capital (Moshiri and Nikpour 2010). Almost all firms and consumers use computers and Internet connection for economic purposes, such as providing consumers with a more diversified and customized products, improving product quality, and selling goods and services. However, country data on computer, cell phone, and Internet users illustrate different ICT diffusion rates across countries and between regions, even among those with the same levels of economic development. Nowadays, economists consider ICT as a main factor that contributes to the economic growth of a nation, especially in many newly industrialized countries (NICs) and developing countries. In fact, ICT is the combination of electronics, telecommunications, software, networks, and decentralized computer work stations, and the integration of information media, all of which impact firms, industries, and the economy as a whole (Granville et al. 2000). ICT comprises of a variety of “communication equipment” which includes radio, TV, and communication equipment and software.

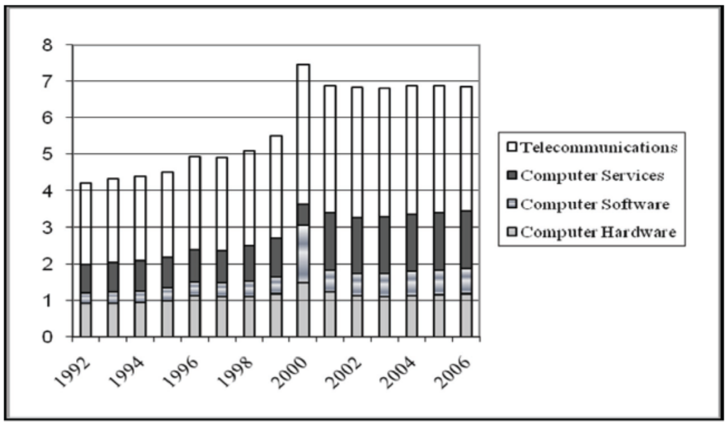

Figure 1: World ICT Spending by its Components (1992-2006) - percent of GDP

Source: Moshiri and Nikpour (2010)

Therefore, ICT investment includes “investments in both computer and telecommunications, as well as related hardware, software and services” (Dedrick et al. 2003). Although many researchers have provided empirical evidences for the correlation between ICT externalities and economic growth, deeper insight in the NICs is still an unexplored area. Therefore, the aim of this study is to fill the literature gap on the effect of ICT investment externalities in NICs. To this purpose, we examine the effect of ICT externalities on GDP growth in NICs. Panel data analysis is applied using data collected from 10 NICs in the period of 1990-2008. Investigating the impact of ICT investment externality on economic growth could have strong policy implications especially for NICs. This paper proceeds with following sections. The next section is a review of relevant studies. Section 3 describes the data collection and research method. In section 4, this study presents the analysis of empirical findings. Finally, Section 5 provides the conclusion of study with a few issues on policy implications.

2- Literature Review

The high growth performance of the United States over the 1990s has attracted the attention of economists to the sources of growth in economy. Some studies have shown that there is no single factor that affects on the growth performance, over the last few years (Scarpetta et al. 2000; Gust & Marquez 2000). ICT plays two basic roles in this process, first through capital deepening which is the result of increasing the overall investment, second by contributing to total factor productivity (TFP) growth. In addition, many empirical studies confirm the effect of ICT investment on growth performance (e.g. Colecchia & Schreyer 2001; Jorgenson 2001; Van Ark et al. 2002). The ICT investment is commonly associated with rapid technological progress in the production of ICT goods and services, which have contributed to a steep fall in ICT prices and encourage investment in ICT. The contribution of ICT to TFP growth is more controversial. Some studies for the United States have argued that the pick-up in TFP in the second half of the 1990s was primarily due to technological progress in the production of ICT goods and services (Gordon 2000). Furthermore, the significant positive impact of ICT investment on economic growth in developed countries has proven (Daveri 2002; Oliner & Sichel 2000; Jalava & Pohjola 2002).

For example, Dewan and Kraemer (2000) estimate a Cobb–Douglas production function with gross domestic product (GDP) as output and ICT capital, non-ICT capital, and labour as inputs. Their results indicate that the returns from ICT capital investments are positive and statistically significant for developed countries, over the period from 1985 to 1993, but non-significant for developing countries. In addition, Pohjola (2001) uses the augmented version of the neoclassical growth model for the cross-section of 39 countries in order to test the impacts of ICT investment on economic growth over the period from 1980 to 1995. Although, his analysis finds no significant impact from human capital and ICT investment on economic growth, investment in ICT appears to have a strong influence on growth in 23 developed countries. Moreover, many studies in developed countries explore the contribution of ICT investment to output growth in these economies. As an illustration, Daveri (2002) chooses 14 European Union (EU) countries and the United States and estimates the contribution of ICT investment. Colecchia and Schreyer (2001) accomplish a similar study for nine countries in the Organization for Economic Co-operation and Development (OECD).

On the other hand, there is an optimistic view suggesting that developing countries may have an advantage over advanced countries with respect to

ICT diffusion. Antonelli (1991) mentions that switching from the predominant technology paradigm to a new “ICT-oriented paradigm” imposed significant costs to developed countries. It can effectively lock these countries into those paradigms and simultaneously, important opportunities open up for less-industrialized countries to catch up and even “leapfrog” beyond the industrialized countries because they have relatively lower switching costs (Seo & Lee 2006). Accordingly, in these literatures using the growth accounting analysis, one of the basic assumptions is that the price of a factor is an indicator for its marginal product. In the case of capital goods it implies that the rental rate per unit of capital, or the user costs of capital, equals the marginal product. Furthermore, the basic neoclassical model assumes that we can measure the current and future marginal productivity of all relevant factors and also the aggregate of private and individual returns are equal to the social returns. This implicitly assumes that there are no externalities involved in the investment in and the use of ICT and this assumption can be doubted on several grounds.

One argument is that ICT as a general purpose technology (GPT) induces various innovations, diffuses widely across industries, and is embedded in a wide range of applications. Bresnahan and Trajtenberg (1995) define GPTs as “technologies characterized by pervasiveness, inherent potential for technical improvements, and innovation complementarities, giving rise to increasing returns-to-scale”. The benefits from these technologies and applications are not immediately clear from the outset and can lead to externalities as knowledge spillovers. Lipsey et al. (2005) consider ICT as a GPT and show that its effect on productivity goes beyond the capital deepening effect. Another main argument points at network effects of ICT, which lead to externalities. Network effects exist when the utility of a product or technology for an individual user depends on the total number of users of that specific product or technology (Meijers 2007). In other words, ICT as a network capital has a characteristic implying that more firms adopting it, the more the benefit that would accrue to existing ICT user firms without the latter bearing extra costs. Bartel et al. (2007) using firm level data in different countries show that there is a positive and significant effect of ICT spillover on firms’ productivity.

Stiroh (2002) uses US manufacturing industry data in his econometric analysis based on the reduced form of the production function and relates

ICT investments to output growth. He finds little evidence for production spillovers or network effects. In another study, Brynjolfsson and Hitt (2003) show positive and significant contributions of computer capital beyond the standard effect of capital on total factor productivity. They also show that there are considerable lags, even as much as up to seven years between the time of investment on ICT capital and its payoff. O'Mahony and Vecchi (2005) estimate the productivity effect of ICT in a production function approach on the sectoral data for the US and UK. Using a Pooled Mean Group (PMG) estimator they show that the standard growth accounting methodology may understate the contribution of ICT to output growth and total factor productivity. Meijers (2007) shows that the impact of ICT capital stock on TFP growth is larger than one would expect from standard neoclassical theory. He also asserts that there is a significant lag before such effects are actually revealed. This could be the reason why Stiroh (2002), who does not include a lag structure in his analysis, fails to find such positive relation.

While there have been numerous studies in US and other developed countries on the effect of ICT externalities on economic growth, less is done in this regard in the NICs. The category of NICs is a socioeconomic classification applied to several countries around the world by political scientists and economists. NICs are countries whose economies have not yet reached the first world status but in a macroeconomic sense, have outpaced their developing counterparts. In the 1970s and 1980s these countries experience a very rapid industrial growth, which attract significant financial investment, and result in high-technology industries. Another characterization of NICs is rapid economic growth and export-oriented. Table1 presents the list of countries consistently considered NICs by different authors and experts (Bożyk 2006; Guillén 2003).

Table1: Economic Index of NICs

Country	GDP (PPP) (Billions of USD, 2009	GDP per capita (PPP) (USD, 2009	Income equality (GINI) 2008	Human Development Index 2010)	GDP (real) growth rate 2009
Mexico	1335	12429	51.61	0.750	-7.4
Brazil	1831	9454	55.02	0.699	-1.1
China	8255	6200	41.53	0.663	8.5
India	3431	2969	36.8	0.519	6.2
Malaysia	349	12723	49.2	0.744	-3.33
Philippines	296	3216	44.5	0.638	-0.73
Singapore	229	45978	48.1	0.846	-4.21
South Korea	1243	25493	31.3	0.877	-0.09
Thailand	492	7260	42	0.654	-2.79
Turkey	838	11208	43	0.679	-5.8

This paper attempts to examine the relationship between ICT investments externalities and economic growth in NICs over the time span of 1990-2008. The main hypothesis is that there is a considerable lag between the time of investing in ICT and the time at which the externalities arise. The possible network effects and spillovers emerging as externalities from investments in ICT are interested in this study. It can be hypothesised that ICT produces a larger productivity than one would expect from a standard neoclassical growth accounting approach. We present the results based on the Generalized Method of Moments (GMM) estimator. Combining data for the 10 countries, we find that ICT capital has a positive impact on output growth and it also has externality effect that is not the same for all countries.

3- Methodology and Data

3-1- The Conceptual Form

The following captures the general framework of growth models with ICT as an explanatory variable:

$$Y_t = A_t F(C_t, K_t, H_t, L_t) \tag{1}$$

Where t is time in all cases, Y is the gross domestic product and Production is possible through ICT inputs (C) and non-ICT inputs: physical capital (K), human capital (H), and labour (L). Based on the following model, ICT impacts on economic growth through two basic ways. First, ICT capital or C used as an input in the production of all goods and services will lead to economic growth. Second, ICT can contribute to technological change and lead to economic growth (Pahjola 2002). In order to estimate the effect of ICT investments on economic growth, there are two different approaches: "the production function approach" and "the growth accounting approach". In the current essay we use the production function approach with the generalized form of the Cobb Douglas production as follow:

$$Y_t = A_t C_t^{\alpha_c} K_t^{\alpha_k} H_t^{\alpha_h} L_t^{\alpha_l} \tag{2}$$

Converting equation (2) into logarithmic form:

$$\ln Y_t = \ln A_t + \alpha_c \ln C_t + \alpha_k \ln K_t + \alpha_h \ln H_t + \alpha_l \ln L_t \tag{3}$$

Based on the network effects and organisational adjustments of ICT capital discussed in the literature, it may take quite some time reaping the benefits from ICT investments. In order to show such lagged influences of ICT investments on economic growth, equation (3) is expanded by including lags for the ICT capital. This specification implies that a change in the stock of ICT capital has an effect on the rate of real economic growth after n years. The extended equation is as follow:

$$\ln Y_t = \ln A_t + \sum_{j=0}^{n} \alpha_{cj} \ln C_{t-j} + \alpha_k \ln K_t + \alpha_h \ln H_t + \alpha_l \ln L_t \tag{4}$$

The last step of the growth accounting approach is to differentiate equation (4) with respect to time:

$$\dot{Y} = \dot{A} + \sum_{j=0}^{n} \alpha_{cj} \dot{C}_{t-j} + \alpha_k \dot{K} + \alpha_h \dot{H} + \alpha_l \dot{L} \tag{5}$$

Where; dots over the variables indicate the rate of change. Assuming constant returns to scale, and each factor receiving its marginal product, the parameters α_{ci}, α_k, α_h and α_l measure the share in total income of ICT input, physical capital, human capital and labour respectively.

3-2- The Empirical Form

In his paper, we choose to work with the production function approach; because it was more widely used in economics and it had less restrictive assumptions. Specifically, our regression model is the following simple double log Cobb-Douglass production function:

$$LnGDP_{it} = \beta_0 + \sum_{j=0}^{n} \beta_{1j} LnICT_{i,t-j} + \beta_2 LnK_{it} + \beta_3 LnL_{it} + \beta_4 LnFDI_{it} + \beta_5 LnOPEN_{it} + U_{it} \quad (6)$$

Which Ln is natural logarithm of the variables, β_0 is a constant coefficient, GDP_{it} is real GDP per capita in constant 2000 prices in US dollar. $ICT_{i,t-j}$ is ICT capital stock in period t and previous years as lagged variables, K_{it} is total capital stock and L_{it} is labour input. FDI_{it} is foreign direct investment as an indicator of technological improvement and according to Papaioannou (2004), we have used foreign direct investment to control for the spillover effects. Since the main characteristic of NICs is trade openness and export orientation, $LnOPEN_{it}$ is used as a proxy of trade openness and measured as the sum of exports and imports of goods and services as a share of GDP, (X + M)/GDP. This method is one of the most traditional and popular measurements of openness (Squalli & Wilson 2006). U_{it} is the model's random error component. The subscripts t and i refer to country and time respectively. In the endogenous growth framework above, we have human capital as an independent variable but in the empirical model we eliminate it regarding to unavailability of proper data.

3-3- The Data

GDP per capita in constant 2000 prices in US dollar has directly obtained from World Development Indicators. Data on labour extracted from the International Labour Organization (ILO). For capital stock, we have referred WDI but the problem is that WDI only provides values for Gross Fixed Capital Formation, which is not really capital stock that we need to substitute in model. We can construct the capital stock from Gross Fixed Capital Formation through the following procedure used by Lee and Guo (2004) called the perpetual inventory method:

$$K_t = I_t + (1-\delta) K_{t-1} \quad (7)$$

Since the capital data for the initial year (1990) is not available, we calculate the benchmark stock from investment series. Assuming a constant growth rate in investment, the benchmark stock K_{t-1} is expressed as follows:

$$K_{t-1} = \frac{I_t}{g + \delta} \tag{8}$$

I_t is investment at period t, g is the average growth rate of investment, and δ is the depreciation rate which is usually assume to be 10% for non-high-tech capital stock. ICT investment data has been collected from International Telecommunication Union (ITU). We use total annual investment in telecommunication in US dollar as a proxy of ICT investment. Since, we need ICT capital stock and not investment in ICT, the perpetual inventory method is applied for this conversion, too. In addition, required data for 10 NIC countries are collected for the period 1985-2008. Since lags of up to 5 years are expected, the model is estimated on the time period 1990-2008. The Data on foreign direct investment were compiled from the statistical resources published by the World Bank.

In order to avoid the misleading regression results, we test the variables for unit root. The results of ADF-Fisher and PP-Fisher tests for unit root in panel data presented in Table 2 indicate that the variables do not have unit root. It should be noted that variables are in logarithmic form and unit root tests are in first difference level.

Table2: The Panel Unit Root Tests

Test	GDP	ICT	K	L	FDI	OPEN
ADF-Fisher Chi-square	62.60***	33.27**	29.52*	71.35***	114.41***	63.24***
PP-Fisher chi-Square	93.77***	291.41***	22.68	155.34***	151.53***	98.44***

Note: * = significant at 5 per cent. ** = significant at 10 per cent. *** = significant at 1 per cent.

3-4- The Estimation Method

The following represents the panel data estimation equation used in this paper:

$$Y_{it} = \delta_i + \Gamma_t + (X_{it})\Phi + \Psi_{it} \tag{9}$$

Where Y_{it} is gross domestic product per capita in constant 2000 prices in US dollar in country i at year t, and X_{it} is a vector of the explanatory variables (ICT capital, total capital stock, labour, trade openness and foreign direct investment) for country i = 1, 2…, m and at time t= 1, 2, …,T, Φ a scalar vector of parameters of β1…., βm; ψ is a classical stochastic disturbance term with E[ψit]= 0 and var[ψit]= σ_{ε}^{2} , δi and Γt are country and time specific effects, respectively.

Since some of the explanatory factors of the traditional growth are either pre-determined, endogenous, or both the growth in the present period could depend on its values in the past. Therefore a dynamic form of Equation (9), known as the Arellano-Bond estimation (1991), which is specified as follows:

$$\Delta Y_{it} = \alpha' \Delta Y_{it-1} + \beta' \Delta X_{it-1} + \gamma' Z_{it} + v_i + \varepsilon_{it} \tag{10}$$

Where ΔY_{it} is first difference of gross domestic product per capita in constant 2000 prices in US dollar in country i during time t, ΔY_{it-1} is lagged difference of the dependent variable, ΔX_{it-1} is a vector of lagged level and differenced predetermined and endogenous variables, Z_{it} is a vector of exogenous variables, and α, β, and γ are parameters to be estimated; ε_{it} ’s are assumed to be independent over all time periods in country i. The term v_i represents country specific effects, which are distributed independently and identically over the countries while ε_{it} noise stochastic disturbance term that also is assumed to be independently distributed. We can find the parameters by making use of the Arellano-Bond (1991) Generalized Method of Moments (GMM) estimator to evaluate the joint effects of ICT investments and other explanatory variables that are used in the economic growth model of NICs while controlling for the potential bias due to the endogenously of some of the regressors.

4- Findings and Discussion

The basis of estimations in this paper is on 10 NICs for the period 1990-2008. In order to distinguish between countries, we divide the sample into three categories, the first is the Organisation for Economic Co-operation and Development (OECD) countries consist of Mexico, South Korea and Turkey; the second is the Association of Southeast Asian Nations (ASEAN) members of this study including Malaysia, Singapore, Philippines and Thailand. The last category is BRIC countries except Russia because of data unavailability. The BRIC countries is a grouping acronym that refers to Brazil, Russia, India, and China supposed to be at the same stage of newly advanced economic development. Therefore, we estimate equation 6 for these three groups; separately. Based on Hausman specification test, the random effects in NICs and three groups rejects in favour of the fixed effects at 95% confidence level. Findings based on the OLS, fixed-effects estimated for equation 6 including lags of 5 years for the ICT variables are summarized in Table 3.

Results indicate that ICT has a positive and statistically significant impact on GDP growth in NICs as a whole. In addition this effect in each subdivision of NICs is significantly positive. Accordingly, we find that each 1% increase in the ICT investment would result in 5, 2, 11 and 3% increase in the GDP growth respectively in NICs, BRIC, OECD and ASEAN countries. Similarly, investment in capital stock (K) and trade openness (OPEN) has a positive and statistically significant impact on the real GDP growth of the sample NICs and also in BRIC and OECD groups. Since in ASEAN countries capital is negative and insignificant but labour and trade openness are positively significant. On the other hand, labour (L) and Foreign Direct Investment (FDI) have positive but insignificant impact on GDP growth in NICs. The results of the lagged ICT variables indicate that however the first lag is negative and significant in all groups, we can find positive impact of these lagged variables like ICT(-5) in NICs, ICT(-2) and ICT(-4) in BRIC and ICT(-3) in OECD countries on economic growth, which are highly significant. The signs of the parameters in lagged variables change from negative to positive suggesting that investments in ICT have a negative impact on economic growth in the very short run however, this is compensated afterwards.

Table 3: Estimation Results using Fixed Effects procedure

Variable	NICs	BRIC	OECD	ASEAN
Constant	-2.86 (-2.32)**	0.20 (0.04)	-14.18 (-7.6)***	-0.8 (-1.49)
ICT	0.05 (2.73)***	0.02 (2.35)**	0.11 (15.5)***	0.03 (3.28)***
ICT(-1)	-0.01 (-3.34)***	-0.04 (-3.85)***	-0.04 (-4.18)***	-0.03 (-3.51)***
ICT(-2)	0.02 (1.54)	0.06 (10.99)***	0.007 (0.84)	-0.001 (-0.19)
ICT(-3)	0.01 (0.82)	0.0005 (0.02)	0.04 (5.41)***	0.005 (0.68)
ICT(-4)	-0.02 (-2.70)***	0.06 (3.36)***	-0.02 (-1.87)*	-0.03 (-3.75)***
ICT(-5)	0.04 (2.72)***	0.1 (34.7)***	0.08 (9.45)***	0.01 (2.39)**
K	0.22 (2.66)***	0.44 (9.65)***	0.58 (16.33)***	-0.007 (-0.21)
L	0.15 (0.86)	-0.84 (-2.81)***	0.2 (1.31)	0.27 (5.47)***
FDI	0.005 (1.41)	0.01 (0.63)	0.009 (6.42)***	0.002 (0.85)
OPEN	0.19 (2.62)***	0.33 (7.79)***	0.19 (5.96)***	0.08 (2.81)***
R-Squared	0.99	0.99	0.99	0.99

Note:
- Dependent variable is the change in the real GDP per capita in constant 2000 prices;
- ICT (-1), ICT (-2), … are lagged variables of ICT;
- All variables are in logarithmic form;
- t-statistics in parentheses;
- ***, ** and * denotes statistically significant at 1%, 5% and 10%, respectively.

The results based on the fixed effects models in which we simultaneously account for the heterogeneity and time fluctuations in the economic performance of NICs, confirm the hypothesis of the paper. However, It should be noted that some explanatory variables in our regression are either pre-determined (trade openness) or endogenous (FDI), thus misleading the results. For example, while FDI has often been appreciated for its role in the economic growth of a country and some studies (Hansen & Rand 2006; de Mello 1999) support that the amount of FDI a country receives is influenced by the level of GDP and its growth rate. Accordingly, we are investigating the effect of ICT investment on NICs economic growth employing the first differences estimator GMM developed by Arellano and Bon (1991) that addresses those problems more effectively and obtain robust estimates. In this method, lagged values of the explanatory variables are used as instruments and an over-identification test is applied to ensure there is no bias due to correlation with the error term. We are also facing the problem of existence of unobservable country specific effects and lagged dependent variables among the explanatory variables. Generalized Method of Moment (GMM) estimator can overcome these problems, too.

Regarding to our extensive data period, 19 years, which is sufficiently large, we do not expect the problem of stability in our results, a problem that Bond (2001) and others are concerned with when the number of observations are small. In the context of GMM, the over-identifying restrictions test via the commonly employed J-statistic of Hansen (1982). The J statistic is distributed as $\chi 2$ with degrees of freedom equal to the number of over-identifying restrictions (L – K). L is the number of instrumental variables and K is the number of explanatory variables. J is the most common diagnostic test in GMM estimation to analyze the appropriateness of the model. A rejection of the null hypothesis shows that the instruments are not properly chosen. This may be either because they are not truly exogenous, or because they are being incorrectly excluded from the regression (Baum et al. 2003). In this paper the J-statistic rejects the null hypothesis of correlation between residuals and instrumental variables in NICs and all three subdivisions. Therefore, the credibility of the results for interpretation is verified and the results can be interpreted in a high level of confidence. Our estimated results based on the Generalized Method of Moments (GMM) -dynamic panel data- are summarized in Table 4. Broadly, the results confirm the expected relationship between GDP growth and ICT investment.

Table 4: Estimation Results of using the Dynamic Panel Method and GMM Estimator

Variable	NICs	BRIC	OECD	ASEAN
GDP(-1)	0.80 (12.2)***	0.72 (5.87)***	0.77 (17.58)***	0.22 (2.86)***
ICT	0.02 (4.66)***	0.003 (0.77)	0.06 (9.92)***	0.01 (3.49)***
ICT(-1)	-0.03 (-7.74)***	-0.01 (-14.4)***	-0.06 (-10.92)***	-0.02 (-8.44)***
ICT(-2)	0.015 (2.03)**	0.008 (2.39)**	0.01 (1.53)	0.004 (0.28)
ICT(-3)	0.006 (1.16)	0.01 (1.32)	0.02 (3.92)***	-0.002 (-0.24)
ICT(-4)	-0.02 (-4.75)***	-0.002 (-0.57)	-0.03 (-9.6)***	-0.04 (-6.93)***
ICT(-5)	0.02 (5.01)***	0.01 (1.25)	0.05 (10.62)***	0.002 (0.88)
K	0.05 (4.00)***	0.12 (1.21)	0.08 (7.6)***	0.26 (3.71)***
L	0.09 (1.14)	-0.008 (-0.08)	-0.15 (-8.71)***	0.17 (0.9)
FDI	-0.0001 (-0.06)	0.0003 (0.04)	0.005 (4.84)***	0.001 (0.58)
OPEN	0.19 (4.82)***	0.11 (2.56)**	0.015 (3.41)***	0.20 (3.59)***
J-statistic Total Observations Instrument rank	131*** 179 12	0.66*** 54 12	0.48*** 57 12	0.39*** 72 12

Note:
All variables are in logarithmic form;
T-statistic in parentheses;
The variables are in the first-difference and Logarithmic form.
GDP (-1) and ICT (-1), ICT (-2), … are lagged variables of GDP and ICT respectively.
***, ** and * denotes statistically significant at 1%, 5% and 10%, respectively.

As Table 4 shows, some lagged variables coefficients of ICT are significantly positive and confirm the existence of ICT externality. These coefficient are consist of ICT(-2) and ICT(-5) in NICs, ICT(-2) in BRIC countries and ICT(-3) and ICT(-5) in OECD category. Furthermore the coefficient of ICT capital is positive and statistically meaningful at 1% significant level for NICs. Since all variables are in logarithm, the value of coefficients represents their elasticity. For example the ICT coefficient 0.02 implying that a 1% increases in ICT investment would lead to a 2% economic growth in these countries. The statistics presented by the World Bank and other international organizations indicate an increasing trend of using ICT in these countries, it means that these countries recognized the important effect of ICT investment on their economic growth. In short, these results verify the meaningful and stable growth inducing effect of ICT investments in NICs. They also verify the hypothesis of this paper that ICT investments externalities have a significant growth generating effect due to the positive lag variable parameters.

In addition, the different effect of ICT investment on economic growth of NICs has shown through its three subdivisions in Table 4. The ICT coefficients for BRIC, OECD and ASEAN are 0.003, 0.06 and 0.01 respectively. This result indicates that the effect of ICT in OECD group is stronger than the other groups. It should be noted that OECD countries have relatively well-developed infrastructures, high ICT investment intensity and advanced human resources in compare with the other two groups. Furthermore in this study we have South Korea in the group of OECD countries which is the second country in the world based on the new ITU ICT Development Index (IDI). This Index compares developments in ICT in 154 countries over a five-year period from 2002 to 2007. IDI combines 11 indicators into a single measure that can be used as a benchmarking tool globally, regionally and at the country level. These are related to ICT access, use and skills, such as households with a computer the number of Internet users; and literacy levels (International Telecommunication Union 2009).

The result of this paper support the studies by Kraemer and Dedrick (2001), Lee et al. (2003) and Pahjola (2001). On the other hand, base on the estimated results, the capital stock (K) coefficient in NICs is 0.05 and statistically meaningful at 1% significant level, which implies that non-ICT investments also have a positive and meaningful effect on economic growth in these 10 countries. This effect is still stronger than that of ICT capital (0.05 vs 0.02). Barro (2001), and Sachsand Warner (2001) reach a different conclusion in this regard. The FDI coefficient is insignificantly negative for NICs but it is positive in three groups, which is only significant in OECD countries. Capital deepening and technical growth are among the main factors of economic growth in any society, but the relatively low value of the estimated coefficients for the FDI variable for the period of 1990-2008 does not reflect this prediction. We have also interred GDP(-1) which is the first lagged variable of the dependent variable in the estimation model because the increase in previous production causes the market to expand, encouraging the introduction of new technologies and the division of labour, which, in turn, generates dynamic increasing returns to scale (Seo & Lee 2006). The results in table 4 show the positive and significance of GDP(-1) in both NICs and groups. The sign of labour input coefficient is positive but not significant. The trade openness coefficient is 0.19 and statistically significant at a high level that implies the positive effect of this variable on economic growth. This result is important because NICs are distinguished from other developing countries for their high rate of trade openness.

5- Conclusions and Implications

This paper concentrated on exploring the supply side of ICT in the NICs. The results of the growth model estimations with ICT as an explanatory variable using Panel Data method in the period of 1990-2008 show that ICT has a significant effect on the economic growth of these countries. This result is obtained after allowing for considerable time lags in the econometric analysis. The coefficients measuring the effect of the ICT investment and its lagged variables on economic growth are mostly positive, indicating that ICT investment affect economic growth of the 10 NICs in a positive way. In addition, positive lags show the externalities effect of ICT on economic growth, which is the main hypothesis of this study. It also points at considerable lags between the time of investment in these technologies and the time at which the externality effects are measurable in output growth. We can also conclude that ICT induces outcomes that goes beyond the effects arise from a standard growth accounting analysis without ICT lagged structure.

The existence of the considerable time lag between investment in ICT and the final payoff may cause the social returns on ICT investment exceed its private return. In such situation policy makers should stimulate investment in ICT. FDI coefficient, which is the technical and technological index of the model, is negative but not meaningful. This shows that foreign direct investment growth does not have a powerful effect on the economic growth of NICs. Consequently, ICT plays a vital role as a mean for economic growth. Therefore, it seems necessary for the NICs to encourage their investment in ICT in order to boost economic growth. The last but not least is that NIC countries cannot get the full benefits of ICT unless they have the suitable infrastructures and skills required for utilizing ICT's capabilities. It is essential for the governments to provide the society with information, up-to-date structures and educated people in other to use ICT efficiently.

Next to externality effects arising from ICT, the paper shows considerable large and positive coefficient for trade openness in the model which result in the strong effect of this variable on economic growth. Therefore, it is crucial for these countries to be more active in attracting international markets to their products and enjoying more ICT capital goods and services in import sector. In other words, policy makers should encourage free trade through decreasing tariffs and eliminating non-tariffs barriers to ICT imports and thereby facilitate economic growth through increasing trade openness index. To fill the gap that exists between Newly Industrialized Countries and the leading countries in the field of ICT development, it is essential to allocate and ensure necessary financial resources for investing in network infrastructures and technology with the aim of providing new potentials in NIC countries.

References

1- Antonelli C. 1991. The diffusion of advanced telecommunications in developing countries. Paris: Organization for Economic Co-operation and Development (OECD).

2- Arellano M. & Bond S. 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies* 58: 277-297.

3- Barro R.J. 2001. Human Capital and Growth. *American Economic Review* 91(2): 12-17.

4- Bartel A., Ichniowski C. & Kathryn S. 2007. How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product Innovation, Process Improvement and Worker Skills. *Quarterly Journal of Economics* 122(4): 1721-1758.

5- Baum C.F., Schaffer M.E., & Stillman S. 2003. Instrumental Variables and GMM: Estimation and Testing. Boston College. *Stata Journal* 3(1): 1-31.

6- Bond S.R., Hoeffler A. & Temple J. 2001. GMM Estimation of Empirical Growth Models. Working Paper. University of Oxford. Available at SSRN: http://ssrn.com/abstract=290522

7- Bożyk P. 2006. "Newly Industrialized Countries". *Globalization and the Transformation of Foreign Economic Policy*. Ashgate Publishing Ltd. pp. 164.

8- Bresnahan T. F. & Trajtenberg M. 1995. General Purpose Technologies: Engines of Growth. *Journal of Econometrics* 65(1): 83-108.

9- Brynjolfsson E. & Hitt L.M. 2003. Computing Productivity: Firm-Level Evidence. *Review of Economics and Statistics* 85(4): 793-808.

10- Colecchia A. & Schreyer P. 2001. The Impact of Information Communications Technology on Output Growth. STI Working Paper OECD, Paris.

11- Colecchia A., & Schreyer P. 2001. ICT investment and economic growth in the 1990s: Is the United States a unique case? A comparative study of nine OECD Countries. STI Working Paper. Paris: Organisation for Economic Co-operation and Development.

12- Daveri F. 2002. The new economy in Europe 1992–2001. *Oxford Review of Economic Policy* 18(3): 345–362.

13- De Mello L.R. 1999. Foreign Direct Investment-led Growth: Evidence from Time Series and Panel Data. *Oxford Economic Papers* 51: 133–151.

14- Dedrick J., Gurbaxani V. & Kraemer K.L. 2003. Information technology and economic performance: A critical review of the empirical evidence. *ACM Computing Surveys* 35(1): 1-28.

15- Dewan S., & Kraemer K.L. 2000. Information technology and productivity: Preliminary evidence from country-level data. *Management Science* 46(4): 548–562.

16- Gordon R.J. 2000. Does the ‘New Economy’ Measure up to the Great Inventions of the Past? *Journal of Economic Perspectives* 14(4): 49-74.

17- Granville B., Leonard C., & Manning J. 2000. Information technology and developing countries: Potential and obstacles. Tokyo Club Meeting, Munich, Germany, 19-20.

18- Guillén Mauro F. (2003). Multinationals, Ideology, and Organized Labor". The Limits of Convergence. Princeton University Press. pp. 126 (Table 5.1). ISBN 0-69-111633-4.

19- Gust C. & Marquez J. 2000. Productivity Developments Abroad. *Federal Reserve Bulletin* 2000(Oct): 665-681.

20- Hansen L. 1982. Large sample properties of generalized method of moments estimators. *Econometrica* 50(3): 1029-1054.

21- Hansen H. & Rand J. 2006. On the causal links between FDI and growth in developing countries. *World Economy* 29(1): 21-41.

22- International Telecommunication Union 2009. Measuring the Information Society: The ICT Development Index, Place des Nations CH-1211 Geneva Switzerland
23- Jalava J. & Pohjola M. 2002. Economic growth in the new economy: Evidence from advanced economies. *Information Economics and Policy* 14(2): 189–210.
24- Jorgenson D. W. & Stiroh K.J. 2000. Raising the Speed Limit: U.S. Economic Growth in the Information Age. Brookings Papers on Economic Activity 31: 125-236.
25- Jorgenson D.W. 2001. Information Technology and the U.S. Economy. *American Economic Review* 91(1): 1-32.
26- Kraemer K.L. & Dedrick J. 2001. *Information Technology and Productivity: Results and Implications of Cross-Country Studies*, In Matti Pohjola (ed)., Information Technology and Economic Development. Oxford: Oxford University Press: 257-279.
27- Lee H. & Khatri Y. 2003. Information Technology and Productivity Growth in Asia. Working paper. Washington: International Monetary Fund.
28- Lee T.S.Y. & Guo X. 2004. Information and Communications Technology (ICT) and Spillover: a Panel Analysis. Paper presented at Econometric Society Far Eastern Meeting 2004.
29- Lipsey R.G., Carlaw K.I., & Bekar C.T. 2005. *Economic Transformations: General Purpose Technologies and Long-Term Economic Growth.* New York: Oxford University Press.
30- Meijers H. 2007. ICT Externalities: Evidence from cross country data, United Nations University - Maastricht Economic and social Research and training centre on Innovation and Technology. Working Paper. Available at: http://www.merit.unu.edu/publications/wppdf/2007/wp2007-021.pdf
31- Moshiri S. & Nikpour S. 2010. *International ICT Spillover, in ICTs and Sustainable Solutions for the Digital Divide: Theory and Perspectives.* edited by Steyn J. & Johanson G. U.S.: Information Science Reference.
32- Oliner S.D., & Sichel D.E. 2000. The resurgence of growth in the late 1990s: Is information technology the story? *Journal of Economic Perspectives* 14(4): 3–22.
33- Oliner S.D., & Sichel D.E. 2002. IT and Productivity: Where Are We Now and Where Are We Going? *Economic Review* 87(3): 15–44.

34- O'Mahony M. & Vecchi M. 2005. Quantifying the Impact of ICT Capital on Output Growth: A Heterogeneous Dynamic Panel Approach. *Economica* 72(288): 615-633.

35- Papaioannou S.K., 2004. FDI and ICT Innovation Effect on productivity growth: A Comparison between developing and developed countries, Athens University of Economics and business, Athens, Greece.

36- Pohjola M. 2001. Information Technology and Economic Growth: A Cross-Country Analysis. In Pohjola, Matti ed., Information Technology and Economic Development. Oxford: Oxford University Press, pp. 242-256.

37- Pohjola M., 2002. The New economy: Facts, impacts and polities. *Information Economics and Policy* 14(2):133-144.

38- Sachs J. & Warner A., 2001. Natural Resource abundance and Economic Development, The Curse of Natural Resource. *European Economic Review* 45: 827-837.

39- Scarpetta S., Bassanini A., Pilat D. & Schreyer P. 2000. Economic Growth in the OECD Area: Recent Trends at the Aggregate and Sectoral Levels, OECD Economics Department Working Papers, OECD, Paris.

40- Seo H.J. & Lee Y.S. 2006. Contribution of information and communication technology to total factor productivity and externalities effects. *Information Technology for Development* 12(2): 159-173.

41- Squalli J. & Wilson K. 2006. A New Approach to Measuring Trade Openness. Economic & Policy Research Unit Working Paper No. 06-07. Zayed University, Dubai, UAE.

42- Stiroh K.J. 2002. Are ICT Spillovers Driving the New Economy? *Review of Income and Wealth* 48(1): 33-57.

43- Van ark B., Melka J., Mulder N., Timmer M. & Ypma G. 2002. ICT Investment and Growth Accounts for the European Union, 1980-2000. DGECFIN, European Commission, Brussels, available at: www.eco.rug.nl/ggdc/homeggdc.html

44- World Bank, 2010, World Development Indicator.