The Impact Of Information And Communication Technology Investment On Economic Growth In Newly Industrialized Countries In Asia

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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 processes. 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. In this paper, we estimate the endogenous production growth model, using panel data of the Newly Industrialized Countries (NICs) in Asia, namely Singapore, South Korea, Hong Kong and Malaysia over the period of 1990-2007. We find a strong significant positive impact of ICT investment on economic growth for these countries. This implies that if these countries seek to enhance their economic growth, they need to implement specific policies that facilitate investment in ICT.

Key words: Economic growth, Information and Communication Technology, Newly Industrialized Countries.

INTRODUCTION

It is widely recognized that in the recent decades, the nature of the global economy has changed toward personal computers, the Internet, cell phone and broadband networks. At the present time, Information and Communication Technology (ICT) has become a serious part of economy. 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 economies (NIEs) 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 (Granville et al. 2000), all of which impact firms, industries, and the economy as a whole. ICT is comprised of a variety of “communication equipment” which includes radio, TV, and communication equipment and software. Therefore, ICT investment includes “investments in both computer and telecommunications, as well as related hardware, software and services” (Dedrick et al. 2003).

In this article, we would like to examine the relationship between investment in ICT and GDP growth in NICs in Asia. Although many researchers have provided empirical evidences for the correlation between ICT and economic growth, deeper insight in NICs is still an unexplored area. Therefore, this article would fill the literature gap on the effect of ICT investment in NICs. We deployed panel data analysis for the sample of four NICs in the period of 1990-2007. If the positive impact of ICT investment is empirically proven, it may have strong policy implications especially for NICs.

The organization of the paper is as follows: The next section is a review of relevant studies on the impact ICT on Economic growth. Section 3 presents the data and methodological framework. Section 4 shows the empirical findings and discussion on the possible imitations. Finally, Section 5 concludes the article with a few issues on policy implications.

2. Literature Review:

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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 (Scarpetta et al. 2000; Gust & Marquez 2000) have shown that there is no single factor that affects on the growth performance, over the past few years. 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 growth. Many empirical studies (e.g. Colecchia & Schreyer 2001; Jorgenson 2001; Van Ark et al. 2002) confirmed the effect of ICT investment on growth performance. The ICT investment is commonly associated with rapid technological progress and competition 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 that ICT has made 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 (Colecchia & Schreyer 2001; Daveri 2002; Dewan & Kraemer 2000; Olner & Sichel 2000; Schreyer 2000; Jalava & Pohjola 2002; Pohjola 2001). For example, Dewan and Kraemer (2000) have estimated a Cobb–Douglas production function with gross domestic product (GDP) as output and ICT capital, non-ICT capital, and labor 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) used 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 has done for developed countries and explored the contribution of ICT investment to output growth in these economies. Daveri (2002) chose 14 European Union (EU) countries and the United States and has estimated the contribution of ICT investment. Similar study for nine countries in the Organization for Economic Co-operation and Development (OECD), Colecchia and Schreyer (2001) has done.

On the other hand, there is some optimistic view which suggests that developing countries may have an advantage over advanced countries with respect to ICT diffusion. Antonelli (1991) mention that switching from the predominant technology paradigm to a new “ICT-oriented paradigm” imposed significant costs to developed countries which 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).

While there have been numerous studies in US and other developed countries on the effect of ICT on economic growth, less is done in this regard in the NICs in Asia. The category of newly industrialized country 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. Another characterization of NICs is that of nations undergoing rapid economic growth and export-oriented. Table 1 presents the list of countries consistently considered as Asian NICs by different authors and experts (Bożyk 2006; Guillén 2003).

This paper is intended to examine the relationship between investments in ICT and economic growth in NICs over the time span of 1990-2007. The data are based on the World Bank (2010) and International Telecommunication Union (ITU).

The main hypothesis of the paper is that the effect of ICT on economic growth is positive and significant. We present results based on the Generalized Method of Moments (GMM) estimator. Combining data for the four countries, we find that not only has ICT a positive impact on output growth, but it also produces excess returns compared with more traditional capital assets.

### 3. Methodology And Data:

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP (PPP) Billions of USD, 2009</th>
<th>GDP per capita (PPP) USD, 2009</th>
<th>Human Development Index, 2001</th>
<th>GDP (Real growth) 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysia</td>
<td>539</td>
<td>12723</td>
<td>0.744</td>
<td>1.55</td>
</tr>
<tr>
<td>Singapore</td>
<td>229</td>
<td>45978</td>
<td>0.846</td>
<td>-0.21</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>322</td>
<td>45277</td>
<td>0.862</td>
<td>-2.76</td>
</tr>
<tr>
<td>Korea</td>
<td>2425</td>
<td>24903</td>
<td>0.877</td>
<td>-0.90</td>
</tr>
</tbody>
</table>

This table presents the list of countries consistently considered as Asian NICs by different authors and experts (Bożyk 2006; Guillén 2003).
3.1. The Conceptual Form:
The following captures the general framework of growth models with ICT as an explanatory variable:

\[ Y_t = AF(C_t, K_t, H_t, L_t) \]  

(1)

Where \( t \) is time in all cases and \( Y \) is the gross domestic product and Production is possible through ICT inputs (C) and non-ICT inputs: physical capital (K), human capital (H), and labor (L).

ICT impacts on economic growth, productivity and production 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 have used the production function approach with the generalized form of the Cobb Douglas production as follow:

\[ Y = A C^{\alpha_c} K^{\alpha_k} H^{\alpha_h} L^{\alpha_l} \]  

(2)

I have eliminated the subscript \( t \) (standing for time) for simplicity and then converting to logarithmic form:

\[ \ln Y = \ln A + \ln C + \alpha_c \ln K + \ln H + \alpha_h \ln L \]  

(3)

The last step of the growth accounting approach is to differentiate (3) with respect to time:

\[ \dot{Y} = \dot{A} + \dot{C} + \alpha_c \dot{K} + \alpha_h \dot{H} + \alpha_l \dot{L} \]  

(4)

Where; dots over the variables indicate the rate of change. Assuming constant returns to scale, and each factor receiving its marginal product, the parameters \( \alpha_c, \alpha_k, \alpha_h, \text{ and } \alpha_l \) measure the share in total income of ICT input, physical capital, human capital and labor 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 (Model A):

\[ \ln GDP_{it} = \beta_0 + \beta_1 \ln ICT_{it} + \beta_2 \ln K_{it} + \beta_3 \ln L_{it} + \beta_4 \ln FDI_{it} + \beta_5 \ln OPEN_{it} + u_{it} \]  

(Model A)

Which \( \ln \) is natural logarithm of the variables, \( \beta_0 \) is a constant coefficient, \( GDP_{it} \) is real GDP in constant 2000 prices in US dollar, \( ICT_{it} \) is investment in ICT, \( K_{it} \) is capital stock, \( L_{it} \) is labor input. \( FDI_{it} \) is foreign direct investment as an indicator of technological improvement and according to Papaioannou and Sotiris (2004), we have used foreign direct foreign 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.

In order to distinguish between countries, we also use the interaction between following three dummy variables for the category of four countries and ICT investment:

- \( Ds \): 1 if the country is Singapore and 0 otherwise;
- $D_h$: 1 if the country is Hong Kong and 0 otherwise;
- $D_k$: 1 if the country is Korea and 0 otherwise.

Therefore the model is as follows (Model B):

$$
\ln GDP_{it} = \beta_0 + \beta_1 \ln ICT_{it} + \beta_2 \ln K_{it} + \beta_3 \ln L_{it} + \beta_4 \ln FDI_{it} + \\
+ \beta_5 \ln OPEN_{it} + \beta_6 D_s \ln ICT_{it} + \beta_7 D_h \ln ICT_{it} + \beta_8 D_k \ln ICT_{it} + U_{it}
$$

(Model B)

### 3.3. The Data:

GDP in constant 2000 prices in US dollar has directly obtained from World Development Indicators. Data on labor extracted from the International Labour Organization (ILO). For capital stock I 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 A). 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:

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

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:

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

$I_t$ is investment at period $t$, $g$ is the average growth rate of investment, and $\delta$ 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). I have used total annual investment in telecommunication in US dollar as a proxy of ICT investment. The data on foreign direct investment were compiled from the statistical resources published by the World Bank.

### 3.4. The Estimation Method:

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

$$
Y_{it} = \delta X_{it} + \Gamma_{it} + \Phi + \Psi_{it}
$$

where $Y_i$ is gross domestic product in constant 2000 prices in US dollar in country $i$ at year $t$, and $X_{it}$ is a vector of the explanatory variables (investment in ICT, capital stock, trade openness and foreign direct investment as an indicator of technical and technological improvement) for country $i = 1, 2, ..., m$ and at time $t = 1, 2, ..., T$. $\Phi$ a scalar vector of parameters of $\beta_1, ..., \beta_m$; $\psi_{it}$ is a classical stochastic disturbance term with $E[\psi_{it}] = 0$ and $\text{var}[\psi_{it}] = \sigma^2_{\varepsilon}$, $\delta_i$ and $\Gamma_t$ 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 (7), known as the Arellano-Bond estimation (1991), which is specified as follows:

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

where $\Delta Y_{it}$ is first difference of gross domestic product in constant 2000 prices in US dollar in country $i$ during time $t$, $\Delta Y_{it-1}$ is lagged difference of the dependent variable, $\Delta X_{it-1}$ is a vector of lagged level and differenced predetermined and endogenous variables, $Z_{it}$ is a vector of exogenous variables.
variables, and $\alpha$, $\beta$, and $\gamma$ are parameters to be estimated; $\varepsilon_i$’s are assumed to be independent over all time periods in country $i$. The term $\nu_i$ represents country specific effects, which are independently and identically distributed over the countries while $\xi_i$ 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:

In effect, four Asian NIC countries for the period 1990-2007, include: Singapore, Hong Kong, South Korea and Malaysia form the basis of estimations in this paper. Findings based on the OLS, fixed-effects and random-effects estimated for model A and B are summarized in Table 2.

Based on Hausman specification test, the random effects in both models rejects in favor of the fixed effects at 95% confidence level. Results indicate that ICT has a positive and statistically significant impact on GDP in fixed-Effects model for NICs. Accordingly, we find that a 1% increase in the ICT investment of typical NICs would result in a 3% increase in the GDP. Similarly, investment in capital stock ($K$) as measured by the gross fixed capital formation and trade openness ($OPEN$) have a positive and statistically significant impact on the real GDP of the sample NIC economies. On the other hand, labor ($L$) and Foreign Direct Investment ($FDI$) have positive but insignificant impact on GDP in these countries.

The results based on the fixed and random 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, 18 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.

Our estimated results from model A and B based on the Generalized Method of Moments (GMM) -dynamic panel data- are summarized in Table 3. Broadly, the results confirm the expected relationship between the Gross Domestic Product, ICT investment and other variables. Furthermore, the variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model A</th>
<th>Model B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fixed-Effects Coefficient</td>
<td>Random-Effect Coefficient</td>
</tr>
<tr>
<td>Const</td>
<td>12.68 (5.87)**</td>
<td>1.18 (1.04)</td>
</tr>
<tr>
<td>Log(IC)</td>
<td>0.03 (1.65)**</td>
<td>0.15 (2.10)**</td>
</tr>
<tr>
<td>Log(K)</td>
<td>0.17 (2.77)**</td>
<td>0.56 (10.3)**</td>
</tr>
<tr>
<td>Log(N)</td>
<td>0.12 (1.40)**</td>
<td>-0.10 (-2.08)**</td>
</tr>
<tr>
<td>Log(FD)</td>
<td>0.01 (1.41)**</td>
<td>0.11 (3.22)**</td>
</tr>
<tr>
<td>Log(OPEN)</td>
<td>0.16 (4.20)**</td>
<td>0.55 (6.57)**</td>
</tr>
<tr>
<td>$\Delta$Log(IC)</td>
<td>-</td>
<td>0.01 (0.41)</td>
</tr>
<tr>
<td>$\Delta^2$Log(IC)</td>
<td>-</td>
<td>0.06 (1.49)</td>
</tr>
<tr>
<td>$\Delta^3$Log(IC)</td>
<td>-</td>
<td>-0.04 (-1.21)</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.99</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Note:
- *T*-statistic in parentheses;
- ***,**, and * denotes statistically significant at 1%, 5% and 10%, respectively.
representing the sources of growth have the expected signs. Since our estimated model was in logarithmic form, all the coefficients represent elasticities.

As table 3 shows, all variables have signs that are consistent with theory predictions; based on the familiar Wald Test which has a $\chi^2$ distribution with degrees of freedom equivalent to the number of explanatory variables, the null hypothesis of zero for all coefficients is rejected at 99% confidence level. This means that the estimated coefficients are true in a high level of confidence. In the context of GMM, the over-identifying restrictions may be tested 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. Therefore, the credibility of the results for interpretation is verified and the results can be interpreted in a high level of confidence.

The coefficient of ICT investment is positive and statistically meaningful at the probability level of 90% for NICs. (Model A) Since all variables are in logarithm, the value of coefficients represents their elasticity. For example the ICT coefficient 0.03 implying that a 1% increases in ICT investment would lead to a 3% 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 have a significant growth generating effect.

In addition, the different effect of ICT investment on economic growth of the four NICs in Asia has shown in model B. The ICT coefficients for Malaysia, Singapore, Hong Kong and Korea are 0.04, 0.05, 0.03 and 0.05, respectively. This result indicates that ICT investment plays a similar role in Singapore and Korea. Furthermore, the effect of ICT in these two countries is stronger than others. It should be noted that in comparing Malaysia with other three countries based on the impact of ICT on economic growth, only the differences between Malaysia and Hong Kong is significant. 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 of model B, the capital stock (K) coefficient in the estimated model is 0.14 and statistically meaningful at the probability level of more than 90% which implies that non-ICT investments also have a positive and meaningful effect on economic growth in these four countries. This effect is still stronger than that of ICT capital (0.14 vs 0.03). Levine and Renelt (1992), Barro (2001), and Sachsand Warner (2001) reach a different conclusion in this regard.

The foreign Direct Investment (FDI) coefficient as an indicator of the technical and technological indices of the model is equal to 0.01 but not significant at even 90% confidence level. Capital
deepening and technical growth are among the main factors of economic growth in any society, but the relatively low value of the estimated coefficient for the FDI variable for the period of 1990-2007 does not reflect this prediction.

The sign of labor input coefficient is positive but not significant. The trade openness coefficient is 0.21 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. Finally, the main findings of this paper on the effect of ICT on economic growth are close to those of Nour (2002).

5. Conclusions And Implications:

This paper concentrated on exploring the supply side of ICT in the Asian NIC countries. The results of the growth model estimations with ICT as an explanatory variable using Panel Data method in the period of 1990-2007 show that ICT has a significant effect on the economic growth of these countries. The coefficient measuring the effect of the ICT investment on economic growth was positive, indicating that ICT investment affect economic growth of the four NICs in a positive way. Foreign Direct Investment coefficient, which is the technical and technological index of the model, is positive but not meaningful at the probability level of about 90%. 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 Asian 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 order to use ICT efficiently. Since trade openness in the model has a positive and highly significant effect on economic growth, 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 NICs 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.

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