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Research Article

The Impact of Information and Communication Technology Availability on Economic Growth

Maryam Farhadi and Rahmah Ismail
Department of Accounting, Islamic Azad University, Mobarakeh Branch, Isfahan, Iran
School of Economics, Faculty of Economics and Management,
Universiti Kebangsaan Malaysia, UKM Bangi, Selangor, Malaysia

Abstract: This study studies the impact of Information and Communication Technology (ICT) availability on economic growth in different countries and regions of the world. The results indicate that there is a positive relationship between growth rate of real GDP per capita and ICT access index (as measured by the fixed telephone lines per 100 inhabitants, mobile cellular telephone subscriptions per 100 inhabitants, international internet bandwidth per Internet user, proportion of households with a computer and proportion of households with Internet access at home) for 142 countries over the world. This study also finds that ICT access in the high income group has a higher effect on economic growth than other groups. This implies that if these countries seek to enhance their economic growth, they need to implement specific policies that facilitate ICT access.

Keywords: Economic growth, GMM, ICT, information and communication technology access

INTRODUCTION

At the present time, 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. In fact, ICT is the combination of electronics, telecommunications, software, networks and decentralized computer workstations 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. ICT access which is the focus of this study indicates the ICT availability or readiness in a country reflecting the level of networked infrastructure and access to ICTs.

In this study, we would like to examine the relationship between ICT access and growth rate of GDP per capita in 142 countries. Although many researchers have provided empirical evidences for the correlation between ICT investment and economic growth, study on the impact of ICT access on economic growth is still an unexplored area. Therefore, this study would fill the literature gap on the effect of ICT access. We deployed panel data analysis for the sample of 142 countries over the period 2000-2009.

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 (Scarpetta *et al*., 2000; Gust and 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 (Colecchia and 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.

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

Corresponding Author: Maryam Farhadi, Department of Accounting, Islamic Azad University, Mobarakeh Branch, Isfahan, Iran Tel.: + 98-9132199112

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 and Lee, 2006).

Another study that concentrates on the telecommunication development is Lam and Shiu (2010). They use the number of fixed-line and mobile phone subscribers per 100 persons as an index of telecommunication development and indicate that there is a bi-directional relationship between real GDP and telecommunications development for European and high-income countries. Their studies show that countries with competition and privatization in telecommunications have achieved a higher TFP growth than those without competition and privatization. While there have been numerous studies on the effect of ICT investment on economic growth, very few is done about the impact of ICT access on economic growth. The main hypothesis of this study is that the effects of ICT access (as measured by the number of internet users, fixed broadband internet subscribers and the number of mobile subscription per 100 inhabitants) on economic growth is positive and significant. We present results based on the Generalized Method of Moments (GMM) estimator. Combining data for the 142 countries, we find that ICT access has a positive impact on output growth.

METHODOLOGY AND DATA

The conceptual form: This study uses a dynamic panel data model (Shiu and Lam, 2008) to investigate the impact of ICT accesson economic growth. The model is shown as follows:

$$GDP_{it} = \alpha_1 + \sum_{m=1}^{M} \beta_m ICT_{i,t-m} + \sum_{m=1}^{M} \gamma_m GDP_{i,t-m} + \varepsilon_{it} \tag{1}$$

where,

α, β & γ	: The parameters to be estimated
GDP & ICT	: Natural logarithm of real GDP per capita and natural logarithm of ICT access indicator, respectively
m	: The level of lags for these two variables.
i & *t*	: The countries in the sample and the time periods
ε_{it}	: The composite error term which is consists of υ_i the unobserved country-specific effect and u_{it} the idiosyncratic shocks ($\varepsilon_{it} = \mu_i + \upsilon_{it}$)
μ_i	: The unobserved country-specific effect
η_t	: The time period dummy
υ_{it}	: The error term is represented by

In the above equation, the fixed effects (μ_i), such as regional and demographics which are also called time-invariant country characteristics, might be correlated with the explanatory variables which violates the assumptions underlying the classical linear regression model (Gujarati, 2003). Moreover, with regard to dynamics, the presence of lagged dependent variables $GDP_{i,t-m}$ will increase the autocorrelation. In other words, $GDP_{i,t-m}$ are correlated with the fixed effect in the error term and results in the "dynamic panel bias" (Nickell, 1981). First differencing can solve this problem by removing such fixed effects, as follows:

$$GDP_{it} - GDP_{i,t-1} = \sum_{m=1}^{M} \beta_m (ICT_{i,t-m} - ICT_{i,t-m-1}) + \sum_{m=1}^{M} \gamma_m (GDP_{i,t-m} - GDP_{i,t-m-1}) + (\upsilon_{it} - \upsilon_{i,t-1}) \tag{2}$$

There are still following econometric problems in the estimation of Eq. (2), which should be considered:

- There is correlation between the new error term (Δu_{it}) and the differenced lagged-dependent variable ($\Delta GDP_{i,t-m}$).
- Since our data set consists of 142 countries for 10 years; the dynamic pattern of the data cannot be ignored. Moreover, based on the dynamic nature of ICT, ICT access index shows wide variation. In this case the assumptions of stationary of all the variables included in the regression and homogeneity of cross-country coefficients are violated.
- This study encounters the endogeneity problem which caused by the measurement error of the ICT access index, which can produce biased estimated coefficients.

In this case, the simple Ordinary Least Squares (OLS) approach can produce highly misleading results (Pesaran and Smith, 1995; Im *et al*., 2002). Therefore, the empirical analysis for the estimation of Eq. (2) should employ a methodology that accounts for heterogeneous dynamic panels (Pesaran *et al*., 1999). To overcome these issues, economists recommend the use of instrumental variables and more recently panel data techniques such as Pooled Mean Group (PMG), discussed in Pesaran *et al*. (1999) and GMM procedure of Arellano and Bond (1991) introduced to address these problems more efficiently. However, when the number of cross-section observations is quite large and the time-series dimension is relatively small, as is the case in this study, the GMM estimator can produce more consistent estimates (Pesaran *et al*., 1999). Shortly, GMM estimator is useful for panel data with relatively small time dimension, as compared to the number of cross sections (Roodman, 2006).

As a result of the above discussion, the Arellano and Bond (1991) GMM method first proposed by Holtz-Eakin *et al*. (1988) seems to be appropriate for the estimation of the Eq. (2), which addresses the problem of autocorrelation of the residuals and deals with the fact that some of the explanatory variables are endogenous. In this method lags of the dependent and independent variables are used as instruments. In this study, we consider lags up to 4 years and the dynamic panel data model is then applied to the complete panel dataset.

Data: GDP per capitain US dollars at constant 2005 prices, using the Purchasing Power Parity (PPP) exchange rates has directly obtained from World Development Indicators (WDI, 2012). This study calculates the ICT access index following the two reports-measuring the information society in 2009 and 2010-presented by International Telecommunication Union (2009 and 2010). The ICT access index includes five indicators consist of fixed telephone lines per 100 inhabitants, mobile cellular telephone subscriptions per 100 inhabitants, international internet bandwidth per Internet user, proportion of households with a computer and proportion of households with Internet access at home and captures the level of ICT access in more than 150 countries worldwide. The ICT data presented in the reports and used to construct the index are all collected by ITU, mostly through its annual questionnaire sent to governments. For more detail and background to the creation of ICT access index, one can refer to the ITU reports.

RESULTS AND DISCUSSION

Our estimated results based on the GMM -dynamic panel data- are summarized in Table 1. Broadly, the results confirm the expected relationship between the real GDP per capita and ICT access index. As Table 1 shows, the signs of all variables are consistent with theory predictions. The coefficient of ICT access index is positive and statistically meaningful at 1% significance level. It means that the more a country access ICT, the greater is its economic growth. The coefficient of ICT access index is equal to 0.19, indicating that if a country improves the ICT access index by 1%, the economic growth will increase 0.19%. Additionally, the coefficient of the first lagged ICT access index is equal to 0.20 which is also significant at 1% significance level. It means that one percent change in ICT access index of the previous year can increase the growth rate of GDP per capita by 0.20%. The statistics presented by the ITU and other international organizations indicate an increasing trend of ICT access indicators in most of these countries, it means that these countries recognized the important effect of ICT on their economic growth. They also verify the hypothesis of this study that ICT access has a significant growth generating effect. The signs of the first lagged of ICT access index and GDP per capita coefficient are positive and highly significant that implies the positive effect of these variables on economic growth. Moreover, the second and forth lagged of ICT and GDP are negative but insignificant.

In the context of GMM, the over-identifying restrictions may be tested via both the Sargan and Hansen test. The Sargan/Hansen test has a null hypothesis of “the instruments as a group are exogenous”. Therefore, the higher the p-value of the Sargan/Hansen statistic is the better (Roodman, 2006). In comparison the Hansen J statistic is more robust than Sargan. For example, Sargan is not distributed as chi-squared under heteroskedasticity and Hansen is and if this problem is present then it could cause Sargan to incorrectly reject the null.

Table 1: Estimation results using GMM estimator

Variable	Coefficient	S.E.
ICT	0.190	0.05***
ICT (-1)	0.200	0.06***
ICT (-2)	-0.160	0.11
ICT (-3)	-0.130	0.06*
ICT (-4)	-0.007	0.02
GDP (-1)	1.500	0.15***
GDP (-2)	-0.160	0.13
GDP (-3)	0.660	0.19***
GDP (-4)	-0.050	0.07
Wald chi^2 (9)	219785.720***	
Number of obs.	852	
Number of groups	142	
Number of instruments	23	
Arellano-bond test for AR (1) in first differences:		
z = -1.72 Pr>z = 0.08		
Arellano-bond test for AR (2) in first differences:		
z = -1.14 Pr>z = 0.25		
Hansen test of overid. restrictions:		
chi^2 (13) = 19.75 prob.>chi^2 = 0.102		

***, ** and *: Statistically significant at 1, 5 and 10%, respectively; The dependent variable is the first-difference of the Ln (GDP) per capita and all variables are in Logarithm; GDP (-t) and ICT (-t), t = 1, 2, 3, 4 are lagged variables of GDP and ICT access index respectively; Standard errors are heteroskedasticity-consistent

Consequently, this study employs the J-statistic of Hansen (1982) which is distributed as χ^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. 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). Based on the results in Table 1, the Hansen J-statistic fails to reject 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.

Evidently, the full disturbance ε_{it} is presumed auto correlated because it contains μ_i, the fixed effects and the GMM estimator is designed to deal with this problem. In order to test for autocorrelation aside from the fixed effects, we have applied the Arellano-Bond test to the residuals in differences. Since u_{it} is mathematically related to Δu_{it-1} via the shared u_{it-1}term, first-order serial correlation is expected in differences and evidence of it is uninformative. Therefore, to test the first-order serial correlation in levels, we should check the second-order correlation in differences. In

Table 2: Estimation results using GMM estimator based on different income levels

Variable income level	Coefficient High	Upper middle	Lower middle	Low income
ICT	0.14 (0.01)***	0.09 (0.01)***	0.05 (0.02)**	0.04 (0.02)**
ICT (-1)	0.03 (0.02)*	0.20 (0.03)***	0.04 (0.02)*	0.03 (0.01)**
ICT (-2)	-0.10 (0.02)***	0.08 (0.02)***	0.02 (0.02)	0.02 (0.01)***
ICT (-3)	0.002 (0.02)	-0.06 (0.01)***	0.05 (0.02)**	-0.02 (0.02)
ICT (-4)	-0.05 (0.01)***	-0.07 (0.02)***	-0.02 (0.02)	0.01 (0.01)
GDP (-1)	1.73 (0.05)***	0.34 (0.07)***	0.02 (0.21)	0.62 (0.05)***
GDP (-2)	-0.81 (0.06)***	0.13 (0.06)**	-0.01 (0.06)	-0.10 (0.06)*
GDP (-3)	0.10 (0.02)***	-0.02 (0.05)	0.35 (0.08)***	0.15 (0.05)***
GDP (-4)	-0.02 (0.02)	0.13 (0.03)***	0.13 (0.12)	0.06 (0.05)
Wald chi^2 (9)	3.41e^{6***}	1442.10***	700.13***	442.48***
Obs.	276	180	165	135
Groups	46	36	33	27
Ins.	36	25	12	13
AR (1)	Z = -1.69*	Z = 1.66*	Z = 3.24***	Z = 0.61
AR (2)	Z = -0.68	Z = 0.57	Z = 0.41	Z = 0.99
Hansen test	Chi^2 (26) = 35.34	Chi^2 (16) = 18.26	Chi^2 (3) = 3.79	Chi^2 (4) = 4.22

The dependent variable is the Ln (GDP) and all variables are in logarithm form; Figures in parentheses refer to heteroskedasticity-consistent standard errors; ***, ** and *: Statistically significant at 1, 5 and 10%, respectively; GDP (-t) and ICT (-t), t = 1, 2, 3, 4 are lagged variables of GDP and ICT respectively

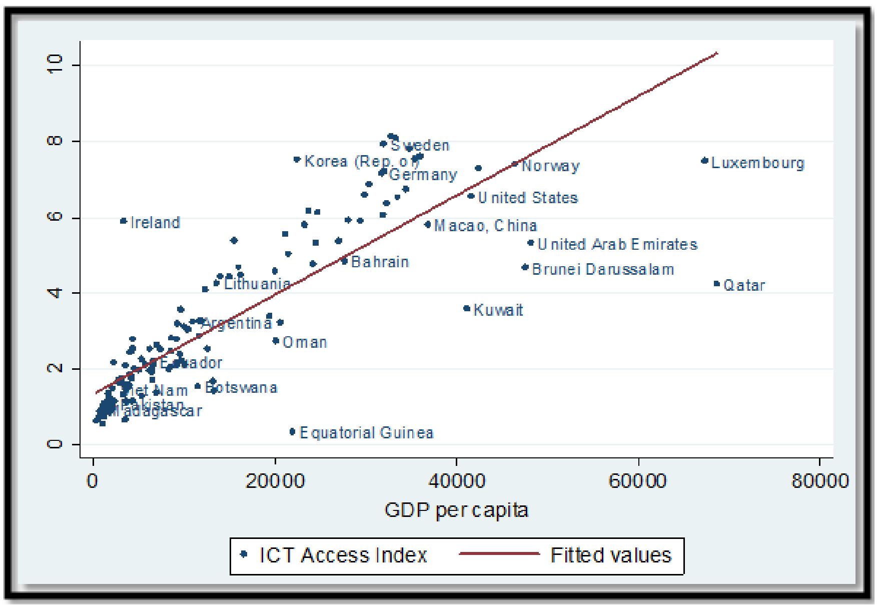

Fig. 1: ICT access index and GDP per capita, 2000-2009

general, we check for serial correlation of order *l* in levels by looking for correlation of order *l*+1 in differences.

The Arellano-Bond test for autocorrelation has a null hypothesis of no autocorrelation and based on the above discussion is applied to the differenced residuals. The test for AR (1) processes in first differences rejects the null hypothesis which is expected. The test for AR (2) in first differences is more important, because it will detect autocorrelation in levels.

For further analysis of the impact of ICT access on economic growth, we categorized the sample of 142 countries into four different groups based on the per capita income according to the classification of ITU (2009). The estimation results based on the GMM method for each group are summarizes in Table 2. Based on the table, in all the groups ICT access index has a positive and significant effect on economic growth which is in line with this study hypothesis. Moreover, the ICT coefficient for the high income group is 0.14, which is the highest among the four income groups while this coefficient has its smallest value of 0.04 in the low income group. It means that one percent change in ICT access index can increase the GDP per capita of a high income country 3.5 times more than a low income country. Table 2 also shows that the first lagged of ICT access index for all income groups is positive and significant. These empirical results are consistent with the findings of Lam and Shiu (2010).

To shed more lights on the differences of countries regarding to ICT access index, following figures are presented. Figure 1 illustrates the positive relationship between average ICT access index and average GDP

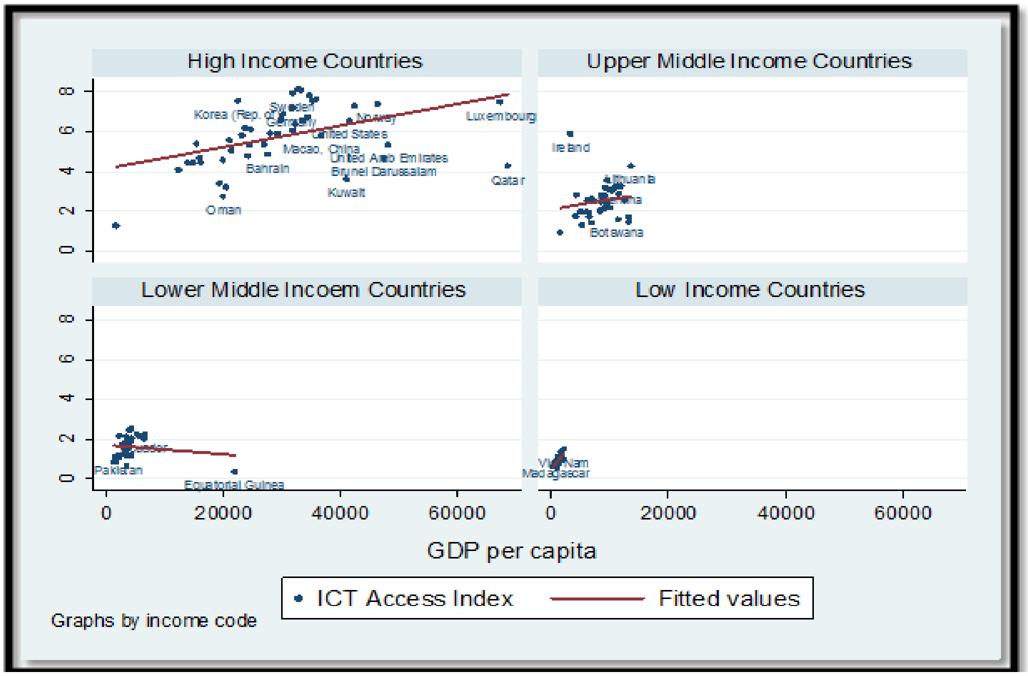

Fig. 2: ICT access index and GDP per capita by income level, 2000-2009

per capita in the total sample of 142 countries over the period 2000 to 2009. The distribution of countries around the trend line is mostly homogenous in low income countries rather than high incomes. The scatter plot (Fig. 1) shows that some countries like Qatar, Brunei Darussalam, United Arab Emirates and Kuwait have a relatively high income level given their ICT access level. These countries are located far below the trend line and are mostly oil exporting countries. It seems that the above mentioned countries are following different economic strategies which are basically related to their natural resources.

There are also countries far above the trend line including Korea, Sweden, Ireland and Germany with the relatively low GDP per capita rather than their ICT access values. This fact indicates how targeted policies, which focus on ICT access, can drive economic growth even in a country with rather low income per capita.

Additionally, Fig. 2 illustrates the correlation between ICT access index and real GDP per capita over the period 2000 to 2009 separately for each income group including high, upper middle, lower middle and low income group, respectively. The distribution around the trend line is fairly homogenous; especially in low and lower middle income countries. As expected the highest value of the ICT access index is allocated to high income countries and the lowest value of this index is related to the group of low income countries. These findings can confirm the between groups differences in the estimated coefficients of ICT access index in Table 2.

CONCLUSION AND IMPLICATIONS

This study concentrated on exploring the effect of ICT access index on economic growth. The results show that ICT access has a significant effect on the economic growth of these countries. The coefficient measuring the effect of the ICT access on economic growth was positive, indicating that ICT affect economic growth of the 142 sample countries in a positive way. Furthermore, in high income counties ICT access index has the strongest effect on real GDP per capita among the others since low income countries are affected by ICT access index less than others. Therefore these countries can improve their overall GDP growth with policies aimed at increasing ICT availability.

Consequently, ICT plays a vital role as a mean for economic growth. Therefore, it seems necessary for all countries to increase their ICT access index through increasing the number of fixed telephone lines per 100 inhabitants, mobile cellular telephone subscriptions per 100 inhabitants, international internet bandwidth per Internet user, proportion of households with a computer and proportion of households with Internet access at home, in order to boost economic growth. It is also essential for the governments to provide the society with information, up-to-date structures and educate people in order to use ICT efficiently. The major research limitation of this study was the failure to collect data for a longer time period. Therefore future research for a longer time span would shed more light in the assessment of the relationship between ICT access and economic growth.

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