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Impact of Information and Communication Technology on the Productivity of South Asian Economies

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ABSTRACT

Information and communication technology (ICT) is considered as an important factor of production, it plays a pivotal role in enhancing the productivity of others factor of production. The main objective of this paper is to find the impact of information and communication technology on the productivity of emerging economies of South Asia. We use GDP per worker as a proxy for productivity and ICT- capital per worker is used to capture the impact of information and communication technologies. We apply OLS and GMM methods of estimation in a panel setting. The results indicate that information and communication technology is one of the main determinants of the variation in output per worker across the four South Asian economies during the last two and half decades (1990-2014). The physical capital which not relates to information technology is also important determinants of productivity growth. The study confirms that ICT is playing important role in South Asia. Therefore, the importance of information technology in economic growth is a global phenomenon

Keywords: Productivity, economic growth, ICT-capital, panel data.

1. INTRODUCTION

Information technology has captured huge interest among the economists since early 1990,s. Although interest in this topic has grown substantially, empirical findings produced mixed results. One school of thought suggests that ICT is not an isolated source of productivity, it is a part of a system that reinforces different organizations and factors to coordinate. Therefore, ICT may not be the main source of productivity. On the

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contrary, some empirical findings show that information technology can raise economic growth in the long run by increasing the productivity level (Bresnahan, Brynjolfsson, & Hitt, 1999a) Another study by (Griffith, Redding, & van Reenen, 2004) also indicates that information technology is positively related to productivity.

Information and communication technology increases investment which affects the price of ICT, the prices of ICT fall and raises the scope of ICT use. Secondly, adoption of technology decreases the prices of new capital and it raises the economic growth (Colecchia & Schreyer, 2002). Information and communication technologies are a very important factor of output growth in the modern era. The Hugh number of empirical studies provides evidence of the strong relationship between information technology and productivity in the developed world (Holt & Jamison; Kretschmer) but the relationship between ICT and productivity is still an interesting area of research in developing the world. The ICT industries in emerging economies are still underdeveloped. These economies are far away from ICT-industry expansion and diffusion due to a shortage of capital and information (Meng & Li, 2002).

The role of ICT in productivity growth is significant in the developed world, it is still insignificant sources for the productivity of underdeveloped economies (Dewan & Kraemer, 2000). Since 2003, South Asian economies specially India is growing very fast. The industrial and services sector is growing rapidly in India and Pakistan. This growth is driven by capital investment. These economies have the industrial capacity and mass markets in spite of low income. Therefore, in this study, we could try to fill the literature gap by analyzing the relationship between ICT- capital and productivity growth in some emerging economies of South Asia -

This study captures the impact of information and communication technology on productivity. This study also analyzed the role of non-ICT capital in productivity. The impact of ICT capital per worker, as well as Non-ICT capital per worker, has a positive impact on productivity growth. Empirical analysis also concludes that contribution of ICT capital is an effective involving time lag.

We review literature in section 2. The presentation of models and estimation procedures is in section 3, data and variables are in section 4, section 5 presents the results and conclusion are in section 6.

2. LITERATURE REVIEW

Technological progress is very important for productivity. According to endogenous growth theory, technological progress is one of the main determinants of productivity. The relationship between a factor of production and economic growth is positive. The sources which affect the marginal productivity of factors of production is also an interesting area of research for scholars and policymakers.

According to new growth theories, long-run economic growth is determined by technological progress (Aghion & Howitt, 1998; Romer, 1990; Solow, 1957). A study by (Kretschmer) found that progress in information technology is the main factor behind uninterrupted productivity growth in the United States. Another study by Niebel which is mentioned in ("Accelerating growth,") found that information technology has a considerable impact on the economic growth of developing economies but this impact was lower in the developed world. Another study by (Yousefi, 2011) evaluated the impact of ICT development on growth for developing countries. This study found information technology has a positive impact on these economies. This result is quasi-equal to that of the South Asia.

The World Bank highlighted the positive contribution of information technology to curb the corruption in developing and developed the world. This report is published in 2012, it also highlighted the importance of ICTs for economic growth. The capital related to information technology accelerates the economic growth (Bresnahan, Brynjolfsson, & Hitt, 1999b). Information and communication technologies contribute directly to a firm's production and its innovative capacity, it helps the firm to recover from business cycles. A study by (Bresnahan et al., 1999b) shows that in the 21st century computers are complimentary for firms in order to increase their productivity

A study by Van and Piatkowski (2003) found that the capital which is not related to capital is still a one of the major determinants of productivity, this study also found that information technology is contributing positively in developed economies but developing economies are still facing difficulty to absorb the technologies. Advance information and communication technologies have the ability to transform the atypical economy into a modern economy. A study by Ranasinghe (2004) analyzed the relationship between information technology and the labor market in Sri Lanka, this study shows that rural areas are far away from development, the speed of development is very slow in rural areas. Information technology has rapid diffusion in some segments of society, it is accelerating the expansion of labor market and destroying old jobs and creating a new job opportunity.

3. MODEL AND ESTIMATION PROCEDURE

Model: In this section, we discuss a theoretical framework for ICT and productivity nexus. Production function can be written as following,

$$Y = AF(K, L) \quad \text{............................... Eq. 1}$$

Where Y is Gross Domestic Product, K is capital stock and L is labor force. Here, capital is categorized as ICT capital and Non-ICT capital. The aggregate production function takes the form:

$$Y = AF(K_{ICT}, K_{Non-ICT}, L) \text{.....................Eq.2}$$

Here capital stock is divided into ICT capital K_{ict} and Non-ICT capital K_{nict}. A is total factor productivity. Gross domestic product per capita is used as an indicator of productivity. We rewrite equation 2 in intensive form as follows

$$\frac{Y}{L} = A\left(\frac{K_{ICT_{it}}}{L}, \frac{K_{Non-ICT}}{L}, 1\right) \text{...................... Eq. 3}$$

$$y = A(k_{ICT}, k_{Non-ICT}) \text{.....................................Eq.4}$$

In equation 4, productivity (i.e. y) depends mainly upon three factors: technology, ICT capital per worker (i.e. k_{ICT}) and non-ICT capital per worker ($k_{Non-ICT}$). In order to find the impact of ICT capital on productivity, we use following Cob-Douglas production Function

$$y = Ak^{\alpha}{}_{ICT} k^{\beta}{}_{Non-ICT} \text{ ....Eq. 5}$$

Take natural log on both sides, we get following the log-linear model

$$\ln y = \ln A + \alpha \ \ln k_{ICT} + \beta \ln k_{Non-ICT} \text{ ....Eq.6}$$

Now, we use following the econometric model for the analysis of ICT-capital and economic growth nexus. This model is also used by Lee *et al*., (2005) and Niebel (2014).

$$\Delta \ln y_{it} = \alpha_0 + \alpha \ \Delta \ln k_{ICTit} + \beta \Delta \ln k_{Non-ICTit} + u_{it} \text{ ....Eq.7}$$

Where $\Delta \ln y_{it}$ is the growth rate of productivity, $\Delta \ln k_{ICT\,it}$ is the growth rate of capital per worker related to ICT assets and $\Delta \ln k_{Non-ICT\,it}$ is the growth rate of capital per capita related to Non-ICT assets. The subscript "i" is used for cross-section "t" is used for the time period the currently adopted ICT will take significant time period to become familiar and efficient in utilization of that technological equipment.

Estimation Procedure: In this section, we carried out the estimation procedure. In order to estimate Eq.7 by OLS, we need to know the order of integration of all series. Therefore, we apply five different panel unit root tests on the growth rate of productivity ($\Delta \ln y_{it}$), the growth rate of ICT capital per worker ($\Delta \ln k_{ICT\,it}$) and growth rate of Non-ICT capital per worker ($\Delta \ln k_{Non-ICT\,it}$) series. Tests by (Levin, Lin, & James Chu, 2002), (Breitung & Das, 2005), (Pasaran, Im, & Shin, 1995), and Fisher-ADF and PP-tests by (Choi, 2001) are used. The following table summarises these tests.

Table 1. Panel Unit Root Tests

Panel Test	H_0	H_1
(Levin, Lin, & James Chu, 2002)	Series is nonstationary	Series is stationary
(Breitung & Das, 2005)	Series is non stationary	Series is stationary
(Pasaran, Im, & Shin, 1995)	Series is nonstationary	Some cross-sections without Unit Root
Fisher-ADF	Series is nonstationary	Some cross-sections without Unit Root
Fisher PP-test	Series is nonstationary	Some cross-sections without Unit Root

In order to analyze the information and communication technology and productivity nexus, we estimate Eq.7 by OLS and GMM estimation methods. The panel data models are typically estimated with fixed effects or random effect. In this study we consider panel fixed effect model. The fixed effects models allow cross-section heterogeneity. It may be noted that in the presence of lagged dependent variable on the right-hand side of the equation the OLS estimation yields biased estimates. Therefore we apply General Method of Moments (GMM) to the models with lagged dependent variable on the right-hand side. We used lags (i.e. j=2) in equation 7 because currently adopted ICT by labor force will take significant time period to become familiar and efficient in utilization. Time lags are very important for this analysis because many studies show that estimates change due to change in the number of time lags (Jorgenson, 2000). Another study by (Basu, Fernald, Oulton, & Srinivasan, 2003) also highlighted the importance of time lags in ICT productivity.

DATA AND VARIABLES

The scope of this study is confined to some south Asian countries in order to avoid too much variation across economic structures of countries. The four countries considered are India, Bangladesh, Sri Lanka and Pakistan. The annual data is taken from 1990 to 2014 from Groningen Growth and Development Centre. The Variables are taken as follows: Real GDP per capita, capital services provided by ICT asset and capital related to Non-ICT asset and data on labor is taken in the growth of person employed (in thousands of person). We generate productivity, ICT capital per worker and Non-ICT capital per worker series by dividing GDP, ICT capital and non-ICT capital with labor L.

4. RESULTS

In order to find the order of integration, we apply five different panel unit root tests to a panel of series across the countries. Table 5.1 .indicates that all panel first-difference series $\Delta \ln y_{it}$, $\Delta \ln k_{ICT\,it}$ and $\Delta \ln k_{Non-ICT\,it}$ are all stationary at 1% level of significant

Table 5.1. Panel Unit Root Test Results on First Differences

	$\Delta \ln y_{it}$		$\Delta \ln k_{ICT\,it}$		$\Delta \ln k_{Non-ICT\,it}$	
TEST	Test-value	p-value	Test-value	p-value	Test-value	p-value

LLC	-18.78	0.00***	-11.22	0.00***	-7.85	0.00***
Breiuing	-21.13	0.00 ***	-7.65	0.00 ***	-6.90	0.00 ***
IPS	-17.60	0.00 ***	-10.92	0.00 ***	-11.96	0.00 ***
Fisher-ADF	357.19	0.00 ***	203.92	0.00 ***	187.87	0.00 ***
PP-test	40.67	0.00 ***	401.04	0.00 ***	203.76	0.00 ***

*Note: (1) *** * denotes rejection of the null hypothesis. 1%. level of significance.*

In order to analyze the ICT and productivity nexus, we estimate Eq.7 through Ordinary Least Square (OLS) method and generalized method of moments (GMM). For the choice of random effect model (REM) or fixed effect model (FEM), Hausman test is used. Table 1 A in the appendix shows that fixed effect model is more appropriate. Since the p-value is 0.05 which is significant so we accept that fixed effect model is appropriate (Hausman, 1978).

Table 5.2: Relationship between ICT and Productivity from Eq.7

Panel results (N = 4, T = 24, 1990–2014)

	OLS Results			**GMM Results**	
	Model 1 Dep: $\Delta \ln y_{it}$ Level	**Model 2** Dep: $\Delta \ln y_{it}$ Lag=1	**Model 3** Dep: $\Delta \ln y_{it}$ Lag=2	**Model 2** Dep: $\Delta \ln y_{it}$ Lag=1	**Model 3** Dep: $\Delta \ln y_{it}$ Lag=2
Constant	0.72 [0.72] (0.47)	0.54 [0.62] (0.57)	0.49 [0.77] (0.43)	0.50*** [10.33] (0.000)	0.56*** [10.47] (0.00)
$\Delta \ln y_{it-1}$		0.34*** [2.32] (0.03)	0.12*** [10.02] (0.000)	0.44*** [5.90] (0.000)	0.33*** [6.02] (0.000)
$\Delta \ln y_{it-2}$			0.24 [1.09] (0.27)		0.21 [1.61] (0.11
$\Delta \ln k_{ICT\,it}$	.08 [1.56] (0.11)				
$\Delta \ln k_{ICT\,it-1}$		0.10** [1.97](0.047)	0.06** [1.98] (0.048)	0.15*** [7.83] (0.000)	0.11*** [9.98] (0.000)
$\Delta \ln k_{ICT\,it-2}$			0.08*** [4.57] (0.003)		0.16*** [3.37] (0.001)
$\Delta \ln k_{Non-ICT\,i}$	0.12*** [8.72](0.000)				
$\Delta \ln k_{Non-ICT\,i}$		0.23** [2.27] (0.06)	0.14*** [5.97] (0.000)	0.33*** [3.97] (0.000)	0.20*** [5.99] (0.000)

$\Delta \ln k_{Non-ICT\,it}$			0.28*** [10.07] (0.000)		0.31*** [10.33] (0.000)
Observations	92	90	88	80	76
R^2	068	0.85	0.80	0.89	0.82
D.W statistic	2.66	2.58	2.97	2.58	
Hansen test (p value)					0.80
Sargant test (p-value)					0.55
M1					0.60
M2					0.40
Country Dummy	Yes	Yes	Yes	Yes	Yes
Time	Yes	Yes	Yes	Yes	Yes

(1) We mention t- statistics in Prentiss [..] and probability or p-value in small brackets (...)
(2) ***, **, and * denote rejection of null hypothesis at 1, 5 and 10 % level of significance
(3) Hansen test for overidentified restrictions. H0: instruments do not correlate with residuals
(4) M1: Arellano–Bond test of the first-order autocorrelation. H0: There is no first order-autocorrelation
(5) M2: Arellano–Bond test of second-order autocorrelation. H0: There is no second order-autocorrelation

For the sample of the 4 economies over the 25 years, the impact of ICT capital per worker on productivity is insignificant at level and it is significant at the 5% percent level at first lag and it is significant at 1% at second leg of ICT capital per capita in both OLS regression and GMM regression. The results indicate that ICT is one of the main determinants of the variation in productivity across the four emerging economies of South Asia during the last two and half decades (1990-2014). The coefficient of $\Delta \ln k_{ICT\,it}$ in the Model 1 implies that 10 percent increase in the growth of capital which is related to ICT ads 0.8 percent points to productivity growth. The finding of this model also shows that the capital which is not related to ICT and labor are important determinants of productivity.

Results in table 5.2 show the positive impact of information and communication technology-related capital per worker ($\Delta \ln k_{ICT\,it}$) on the growth rate of productivity ($\Delta \ln y_{it}$). The impact of ICT capital per worker on productivity growth is positive but it is statistically insignificant in model 1. This impact becomes significant when we increase the lags (see model 2 and model 3 in table 5.2). This could be due to low return to ICT capital in developing countries; currently adopted ICT by labor force will take significant time period to become familiar and efficient in utilization of that technological equipment. A large number of literature reports negative relationship between the growth of ICT and productivity during 1970's and 1980's, for example, Solow described this negative relationship as productivity paradox (Solow, 1957). On another hand, a huge literature on developed economies supports a positive relationship between ICT and productivity (Jorgenson, 2000). Therefore, results mentioned in table 5.2 support the theory that information technology is one of the main determinants of productivity because capital related to information technology is positively related to productivity growth.

According to Neo-classical growth theory fall in the price of ICT capital may have an indirect effect on investment through substitution of inputs, which raise the productivity of capital and capital deepening. Therefore, the price of ICT effects the value addition and labor productivity. Information technology plays important role in total factor productivity. The importance ICT's for TFP is highlighted by (Stiroh, 2005). Another study by (Jorgenson, 2000) shows that if we allow the differences in productivity across industries then TFP is uncorrelated with capital. The literature on developing countries shows that absorbance and adaptation of ICT are slow in developing countries. This could be the main reason for the insignificant relationship between ICT and productivity in the underdeveloped world. Therefore time lags are a very important factor, we use time lags in order to see the impact ICT on productivity. Our results show that impact of ICT related capital on productivity is significant with lags.

5. CONCLUSION

This study explores the impact information technology on the productivity of South Asia. This study is confined to four south Asian countries in order to avoid too much variation across economic structures of countries. The four countries which are considered in this study are India, Bangladesh, Sri Lanka and Pakistan. We used annual data from 1990 to 2014. In order to analyze the information and communication technology and productivity nexus, we use Ordinary Least Square (OLS) and GMM. We chose fixed effect model. The fixed effects allow heterogeneity across countries.

Our estimates show that the impact of ICT-capital per worker on the growth rate of productivity is positive and it becomes significant with the inclusion of time lags in ICT capital. The study also shows that there is a positive relationship between ICT capital and productivity growth. The impact of Non-ICT capital is also positive and statistically significant on productivity growth. The rate of transmission of ICT capital is very slow in developing countries, therefore, lags are involved to explore the impact of ICT on productivity growth.

The study confirms that the accumulation of capital related to information technology is one of the main determinants of the variation in productivity growth across South Asian economies. The study finds that ICT contribution to productivity is a global phenomenon because it has also a positive impact on the productivity growth of developing countries.

This study found that Information and communication technology (ICT) plays a vital role in productivity growth south Asian economies. Therefore, it is necessary for south Asian countries to increase the use of ICT in order to boost their productivity.

REFERENCES

Accelerating growth. *World Development Report 2016: Digital Dividends* (pp. 48-89).

Aghion, P., & Howitt, P. (1998). *Endogenous Growth Theory*. Cambridge, MA: MIT Press.

Basu, S., Fernald, J. G., Oulton, N., & Srinivasan, S. (2003). The Case of the Missing Productivity Growth or Does Information Technology Explain Why Productivity Accelerated in the United States but Not in the United Kingdom? *NBER Macroeconomics Annual, 18*, 9-63. doi:10.1086/ma.18.3585244

Breitung, J., & Das, S. (2005). Panel unit root tests under cross-sectional dependence. *Statistica Neerlandica, 59*(4), 414-433.

Bresnahan, T., Brynjolfsson, E., & Hitt, L. (1999a). *Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-Level Evidence*. Retrieved from https://EconPapers.repec.org/RePEc:nbr:nberwo:7136

Bresnahan, T., Brynjolfsson, E., & Hitt, L. (1999b). Information Technology, Workplace Organization and the Demand for Skilled Labor: Firm-Level Evidence.

Choi, I. (2001). Unit root tests for panel data. *Journal of International Money and Finance, 20*(2), 249-272.

Colecchia, A., & Schreyer, P. (2002). ICT Investment and Economic Growth in the 1990s: Is the United States a Unique Case? A Comparative Study of Nine OECD Countries. *Review of Economic Dynamics, 5*(2), 408-442.

Dewan, S., & Kraemer, K. L. (2000). Information Technology and Productivity: Evidence from Country-Level Data. *Management Science, 46*(4), 548-562. doi:10.1287/mnsc.46.4.548.12057

Griffith, R., Redding, S., & van Reenen, J. (2004). Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries. *The Review of Economics and Statistics, 86*(4), 883-895.

Hausman, J. A. (1978). Specification Tests in Econometrics. *Econometrica, 46*(6), 1251-1271. doi:10.2307/1913827

Holt, L., & Jamison, M. Broadband and contributions to economic growth: Lessons from the US experience. *Telecommunications Policy, 33*(10-11), 575-581.

Jorgenson, D. W., & Stiroh, K. J.. (2000). Raising the speed limit: US economic growth in the information age". Brookings papers on economic activity.

Kretschmer, T. *Information and Communication Technologies and Productivity Growth*: OECD Publishing.

Levin, A., Lin, C.-F., & James Chu, C.-S. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of Econometrics, 108*(1), 1-24.

Meng, Q., & Li, M. (2002). New Economy and ICT development in China. *Information Economics and Policy, 14*(2), 275-295. doi:https://doi.org/10.1016/S0167-6245(01)00070-1

Pesaran, M. H., Im, K. S., & Shin, Y. (1995). *Testing for Unit Roots in Heterogeneous Panels*. Retrieved from https://EconPapers.repec.org/RePEc:cam:camdae:9526

Romer, P. (1990). Endogenous Technological Change. *Journal of Political Economy, 98*(5), S71-102.

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics, 39*(3), 312-320. doi:10.2307/1926047

Stiroh, K. J. (2005). Reassessing the Impact of IT in the Production Function: A Meta-Analysis and Sensitivity Tests. *Annals of Economics and Statistics*(79-80), 529-561.

Yousefi, A. (2011). The impact of information and communication technology on economic growth: evidence from developed and developing countries. *Economics of Innovation and New Technology, 20*(6), 581-596. doi:10.1080/10438599.2010.544470

Appendix

Table 1A Results of Hausman test:

Test summary	Chi-Sq. Statistic	P-value
H_0: Random effect is applicable	8.90	0.052