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ICT and E-government as the Sources of Economic Growth in Information Age: Empirical Evidence from South Asian Economies

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ABSTRACT

The growing importance of information and communication technologies (ICTs) and e-government has attracted the attention of policy makers who are committed to increase the GDP per capita of a country. Therefore, this study investigates the growth effects of ICT and e-government for a sample of eight South Asian economies over the period 1980-2016. To the best of our knowledge, this is the first empirical study, which examines the relationship between economic growth and ICT with a special emphasis on the role of ICT implementation in public sector. In particular, we use diverse indicators of ICT to assess the robustness of empirical findings. Moreover, the study employs instrumental estimation techniques 2SLS and GMM to deal with the possible problem of endogeneity. The empirical findings of our study indicate that growth effects of ICT as well as e-government are positive and significant in all models. Finally, our study concludes that the South Asia region can greatly benefit from the implementation of ICT infrastructure in general and in public sector in particular.

Key Words: **ICT, E-Government, Economic Growth, South Asia**

Introduction

Information and communication technology (ICT) is regarded as a special case of new technologies that serve as enabling technologies leading to more innovations and increasing economic performance. However, not all developing countries shared the same benefits from ICT as the developed countries (Niebel, 2018). Most of the developing economies are lagging behind in the adoption of ICT infrastructure as a potential source of economic growth. In particular, adoption of ICT infrastructure in government administration (e-government) has received relatively little attention of academicians, development practitioners and policy makers.

The literature shows that investment in ICT infrastructure has positive impact on economic growth as it reduces the communication cost. Koutroumpis (2009) explains that ICT improves communication among firms and contributes to their profits and to overall growth of a country. In the same vein, Mahyideen et al.

(2012) highlighted that information and communication technology increases the productivity of labor force and therefore, accelerates the economic growth of a country. Likewise, Quah (2002) mentioned that ICT improves labor skills, broad based education and consumer sophistication. In addition, ICT can play role in trade facilitation, regional integration and cross border communication. Although, there is a considerable amount of empirical work, which examines the impacts of ICT on economic growth, however, these studies ignore the importance of e-government in explaining economic growth.

The term "e-government" refers to the online accessibility of a government and it is supposed to be fast and efficient as it improves information and knowledge in the services of the citizens. According to UNDP (2006), the term e-government refers to the adoption of ICT tools in public administration for the delivery of its responsibilities toward citizens, businessmen and other stakeholders and it provides services to the masses more efficiently. Although, the theoretical literature discusses the positive impacts of e-government on economic success of a country but empirical studies on e-government are still missing. Particularly, the contribution of e-government for the region of South Asia has not been yet analyzed.

This study contributes to the existing literature and investigates the relationship between economic growth, ICT and e-government for South Asian countries over the period 1980-2016. This study uses evidence from South Asian region and considers diverse indicators of ICT and alternative econometric techniques of estimation for panel data analysis. This study attempts to measure the economic impact of the information and communication technologies on growth and more specifically the effects of implementation of information and communication technologies in public sector that is referred as e-government. Although, this issue has received some regulatory and public policy attention in the developing economies but empirical evidence is much needed for the formulation of policies.

The study is planned as follows. The Section 2 reviews the literature on ICT, e-government and economic growth. The Section 3 explains the methodology, while Section 4 describes the data. The Section 5 provides empirical results and finally, Section 6 concludes the study.

Review of Literature

Investigation of determinants of economic growth is considered the most active research area in economics. However, the growth models varies significantly from exogenous growth models (Solow, 1957) to the endogenous growth models where growth is driven by the technological changes (Romer, 1990). The sub-section 2.1 reviews the literature on ICT and growth nexus while the next sub-section 2.2 reviews the literature on e-government and growth nexus.

2.1. ICT and growth nexus

The term information and communication technology (ICT) refers to all those communication devices and applications (such as computer, mobile phone, television, radio, or satellite system) which enable the users to access, transmit, manipulate or store information. It is assumed that ICT enhances service delivery, increases transparency and improves interaction between government and citizens (Sabri et al., 2012). Similarly, ICT contributes in other sectors of economy such as e-commerce, e-trading and e-banking. For example, ICT reduces communication costs in e-commerce and addresses many limitations of exporters/importers by reducing high entry costs, managing potential market isolation and by maximizing access to information (Xing, 2018). Likewise, ICT improves the cost efficiencies of commercial banks that enhance firm's value of stocks in the market.

Brynjolfsson and Hitt (2000) provide a comprehensive survey of the literature on the links of information technology with higher productivity and organizational transformation. The study argues that performance of IT is subject to the complementary organizational investments which improve the intangible aspects of the production. Similarly, Holt and Jamison (2009) investigate the relationship between ICT, broadband and economic growth for the USA. Although, the study discusses various methodological problems and data constraints, it finds positive impact of broadband deployment on economic growth.

In the same line of argument, Choi and Hoon-Yi (2009) examine the links of internet subscription with economic growth for a sample of 217 countries. The study covers the time period from 1991-2000 and finds that an increase in internet subscription has positive impact on economic growth. According to the study, internet contributes to economic growth by disseminating information and by mitigating information cost. Likewise, Czernich et al. (2011) support the positive relationship between broadband and economic growth for OECD countries over the time period 1996-2007.

Mahyideen et al. (2012) investigate the role of ICT in the economic progress of ASEAN countries for the period 1976-2010. The study employs heterogeneous co-integration techniques and confirms a long-run relationship between ICT and growth. Moreover, the study shows that ICT supplements the marginal productivity of inputs and therefore, contributes to economic growth. In a recent study, Niebel (2018) examines the impact of ICT on economic growth of developed, emerging and developing countries. The study finds excess returns to ICT investments. However, the study highlights that developing and emerging economies are not gaining more from ICT as compared to developed economies. It may be because of the fact that the role of e-government is usually ignored in defining economic growth. However, economic growth is interlinked with e-government.

2.2. E-government and growth nexus

According to Von-Haldenwang (2004) e-government shows the implementation of ICT in public sector administration and planning. E-government, according to Chen et al. (2009), implies that public sector provides rapid, transparent and efficient services through IT services. Since e-government shows digital interactions between a government and other stakeholders, therefore, it is supposed to be fast and efficient (Majeed & Malik, 2016).

As mentioned earlier, theoretical literature supports a positive relationship between e-government and growth. Whereas, e-government assists in diffusion of knowledge and information and it contributes in realizing the actual potential of an economy. E-government improves the efficiency of services provided by the public sector (Von-Haldenwang, 2004). Moreover, it enhances the democracy by strengthening the role of public sector (West, 2004), and it facilitates in the control of corruption by increasing transparency and accountability (Krishnan & Teo, 2012). Likewise, Ma et al. (2005) argue that e-government facilities growth process by controlling corruption and facilitating financial development and trade in a country.

Krishnan et al. (2013) have conducted empirical research for a sample of 105 countries over the time period 2004-2008 and investigated the relationship between e-government, environmental degradation and corruption. The study used Structural Equation Modeling (SEM) and finds a significant impact of e-government on the economic growth of the countries included in the sample. The study explains that e-government influences growth through quality of environment and corruption. In a recent study, Majeed and Malik (2016) analyze bilateral links between e-government, trade and economic growth for a sample of 147 countries. The empirical analysis is based on a system of equations. The study finds evidence of positive links of e-government with both economic growth and trade.

The literature on the linkages of ICT and e-government with growth shows that available studies generally focus on ICT as a source of economic growth. These studies usually use a single proxy of ICT such as internet or telephone and generally focus on the developed economies. In general, the empirical evidence from developing economies and from South Asia is missing in the available literature. In particular, the adoption of e-government in public sector has not been analyzed in the context of South Asia. This study fills these gaps using diverse measures of ICTs and a novel measure of e-government for the South Asian region. The study tests the following hypothesis.

H0: ICT and e-government do not contribute to economic growth of South Asian countries.

H1: ICT and E-government positively affect economic growth of South Asian countries.

The model

The study follows the model given by Mankiw et al. (1992). The model is as follows:

$$y = f(A, k, n, h)$$

$$y_{it} = \beta_0 + \beta_2 A_{it} + \beta_3 k_{it} + \beta_4 n_{it} + \beta_5 h_{it} + \varepsilon_{it} \quad (1)$$

where *y* refers to the real income per capita, *A* denotes the state of technology, *k* represents physical capital, *n* refers to the labor force and *h* is human capital. In this model, state of technology is an important factor and it explains the divergence among per capita income (growth rates) of the countries. The state of technology of a country (region) can be measured by different variables and one such variable is information and communication technologies (Sassi & Goaid, 2013; Majeed & Malik, 2016). Following these studies, we have proxied state of technology by ICT while technological progress has been measured by e-government. It is important to mention that excellence of e-government indicates the adoption and implementation of ICT technologies. Therefore, it is considered a wider proxy for technological progress. Moreover, the e-government includes a comprehensive range of ICT infrastructure and skilled units of labor force to operate e-government. Hence, the equation 1 can be rewritten as equation 2.

$$y_i = \beta_0 + \beta_1 ICT_{it} + \beta_2 k_{it} + \beta_3 n_{it} + \beta_4 h_{it} + \beta_5 Inf_{it} + \varepsilon_{it} \quad (2)$$

Here, ICT refers to the diverse measures of information and communication technologies and it has been decomposed into six indicators. These indicators include mobile phones subscriptions (MPS), internet users (IU), fixed telephone subscriptions (FTS), fixed broadband subscriptions (FBS), telecommunication infrastructure index (TCI) and online service index (OSI). Since these measures are highly correlated, there simultaneous estimations can cause the problem of multicollinearity. Therefore, the study estimate separate effect of each indicator of ICT. Moreover, the expected sign of β_1 is positive and significant because ICT accelerates economic growth. Furthermore, the present study is using inflation (*inf*) as a control variable to examine the robustness of the results for empirical analysis. Thus, following equations will be estimated:

$$y_i = \beta_0 + \beta_1 MPS_{it} + \beta_2 k_{it} + \beta_3 n_{it} + \beta_4 h_{it} + \beta_5 Inf_{it} + \varepsilon_{it} \quad (2.1)$$

$$y_i = \beta_0 + \beta_1 IU_{it} + \beta_2 k_{it} + \beta_3 n_{it} + \beta_4 h_{it} + \beta_5 Inf_{it} + \varepsilon_{it} \quad (2.2)$$

$$y_i = \beta_0 + \beta_1 FTS_{it} + \beta_2 k_{it} + \beta_3 n_{it} + \beta_4 h_{it} + \beta_5 Inf_{it} + \varepsilon_{it} \quad (2.3)$$

$$y_i = \beta_0 + \beta_1 FBS_{it} + \beta_2 k_{it} + \beta_3 n_{it} + \beta_4 h_{it} + \beta_5 Inf_{it} + \varepsilon_{it} \quad (2.4)$$

$$y_i = \beta_0 + \beta_1 TCI_{it} + \beta_2 k_{it} + \beta_3 n_{it} + \beta_4 h_{it} + \beta_5 Inf_{it} + \varepsilon_{it} \quad (2.5)$$

$$y_i = \beta_0 + \beta_1 OSI_{it} + \beta_2 k_{it} + \beta_3 n_{it} + \beta_4 h_{it} + \beta_5 Inf_{it} + \varepsilon_{it} \quad (2.6)$$

Besides, the study estimates the effect of e-government on economic growth of the South Asian countries in a separate model given by equation (3). The segregation of e-government from other measures of ICT is necessary because it only refers to the implementation of ICT in public sector. E-government is considered a key source of economic growth as it controls corruption, improves financial transactions, facilitates trade and alleviates environmental burden. However, implementation of e-government in developing economies comes at the cost of jobs, which can adversely affect economic performance. Therefore, it is important to test it empirically to determine the net effect of e-government (e-*gov*) on economic growth.

$$y_i = \beta_0 + \beta_1 e\text{-}gov_{it} + \beta_2 k_{it} + \beta_3 n_{it} + \beta_4 h_{it} + \beta_5 Inf_{it} + \varepsilon_{it} \quad (3)$$

In the next step, we conduct a principal component analysis of all measures of ICT and generate an aggregate index as follows:

$$y_i = \beta_0 + \beta_1 PCA_{it} + \beta_2 k_{it} + \beta_3 n_{it} + \beta_4 h_{it} + \beta_5 Inf_{it} + \varepsilon_{it} \quad (4)$$

Finally, the equation (4) has been specified to estimate the combined index of ICT on economic growth of South Asian countries.

Data description and statistical analysis

The data for ICT indicators has been taken from International Telecommunication Union (ITU, 2017) whereas, the study considers following proxies for ICT infrastructure. The first proxy for ICT infrastructure is "mobile cellular subscriptions", second proxy is "internet users", third proxy is "fixed telephone subscriptions" and fourth proxy is fixed broadband subscriptions. All these proxies for ICT infrastructure are measured in per 100 people. The fifth variable "telecommunication infrastructure" is a mean value of internet users, mobile subscriptions, fixed broadband subscriptions, fixed telephone lines and number of mobile subscriptions. The study considers "online service index" as its sixth proxy for ICT infrastructure and it ranges from 0 to 1. Lastly, the study considers Principal Component Analysis of ICT indicators for ICT infrastructure.

The data for e-government shows online accessibility of government and web connections to offer its services. The data for e-government is obtained from E-governance Development Index (EGDI). The EGDI includes three components

(skilled labor, web connectivity and telecom infrastructure) while equal weights are given to these three components in the construction of EGDI. The index ranges from zero to one where zero means the worst quality of e-government and one shows the best quality of e-government. The data on e-government is not continuous but has missing values and it starts from 2003. The outcome variable economic growth is real GDP per capita at constant prices of 2011US $ and the data is taken from World Development Indicators (2017). The data for control variables labor force, physical capital, human capital and inflation came from World Development Indicators (2017). Furthermore, the data extracted from e-government Development Index and the World Development Indicators is provided by the United Nations and the World Bank.

The study also presents statistical analysis of these variables and following eight figures are used for this purpose. The Figure 1 shows the average economic growth rates in South Asian countries for the period 1980-2016.

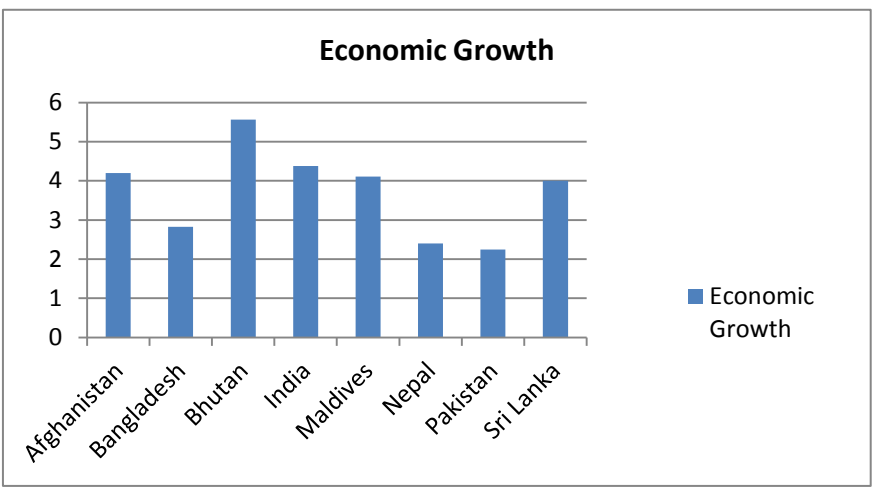


Figure 1: Averaged Economic Growth Rates in South Asia

Figure 1 indicates that on average Pakistan and Nepal are performing low in terms of GDP per capita growth while Bhutan and India are performing high. Overall growth rate of South Asia is 3.74 percent over the period of study.

It is evident from Figure 1 that some economies experience sustained economic growth while others do not? This question has received a great deal of attention from the researcher and different causes of economic growth have been investigated but still much of the growth remains unexplained. Most recently, researchers have focused on ICT as well as e-government as possible sources of economic growth. This study, therefore, investigates the relationship between ICT, e-government and economic growth for south Asian countries.

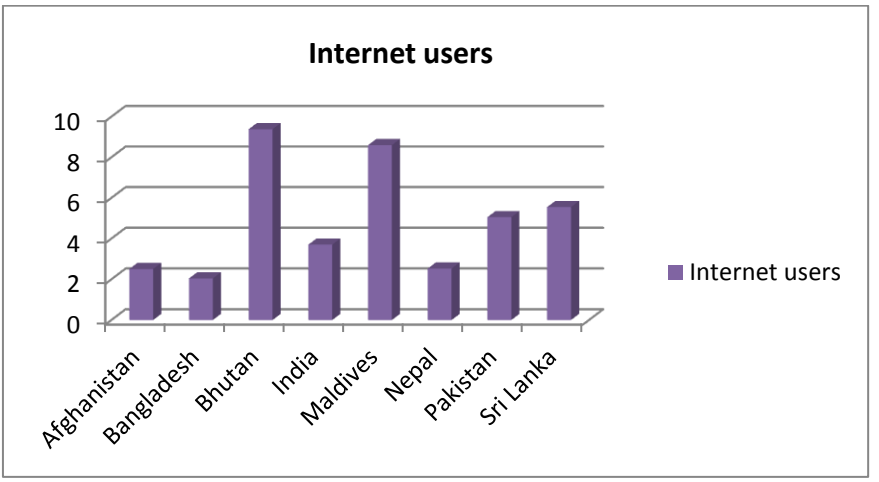


Figure 2: Internet Users

Figure 2 shows the number of internet users per 100 people in South Asian countries. It is evident from the Figure 2 that internet users are rather low in this region. The figure also shows that Bhutan has the highest number of internet users which in effect is very low as only 9 out of 100 people are using internet. The number of internet users significantly drops in other countries of South Asia. For instance, in Nepal only 2 out of 100 people are using internet while in Bangladesh less than 2 people are using internet.

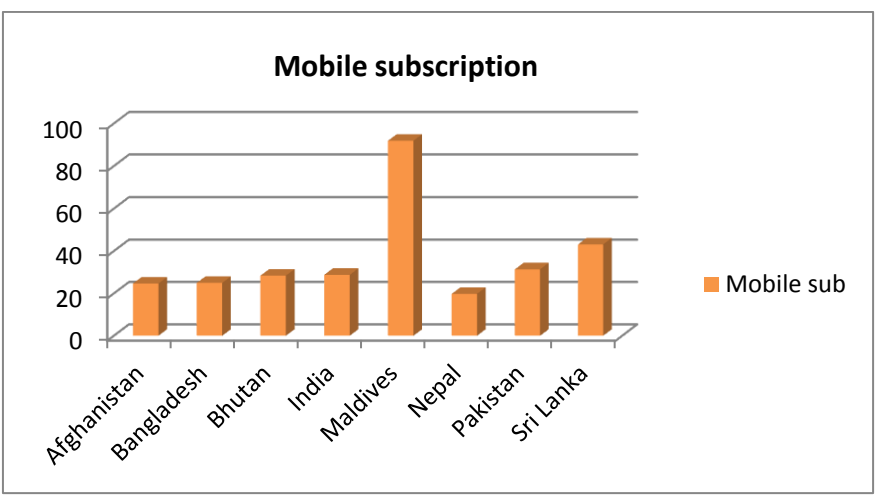


Figure 3: Mobile Subscription

The Figure 3 shows a bar chart of mobile subscription per 100 people in South Asian countries. This indicator is performing better as compared to the use of internet indicator. There is only Nepal where mobile subscription is less than 20

while other countries of this region have this ratio more than 20 out of 100. Maldives, Sri Lank and Pakistan are performing comparatively better on this indicator of ICT.

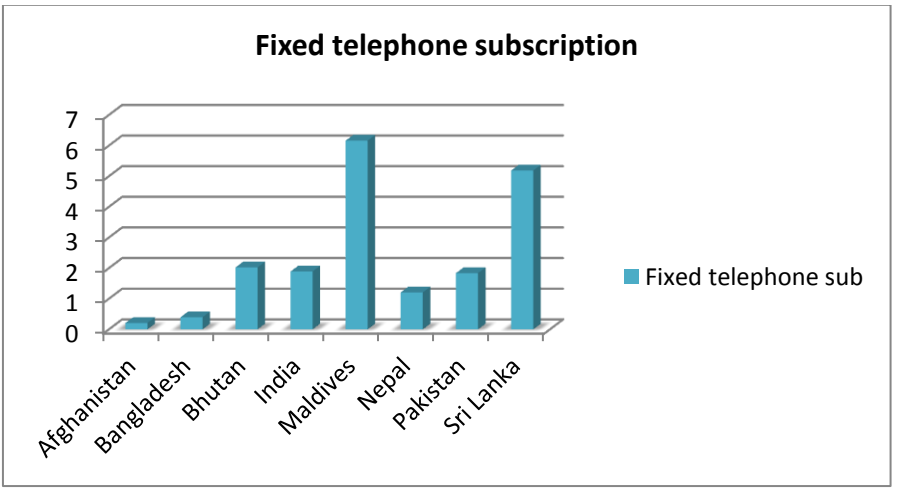


Figure 4: Fixed Telephone Subscriptions

The Figure 4 displays fixed telephone subscription in South Asian countries. The performance of this indicator of ICT is very low. In particular, Afghanistan and Bangladesh are ranked the lowest for fixed telephone subscription. Maldives and Sri Lank are performing comparatively better.

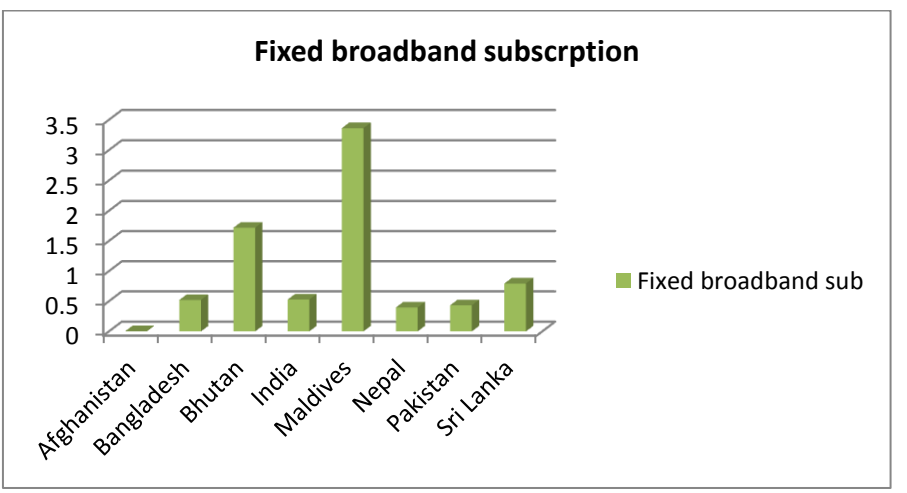
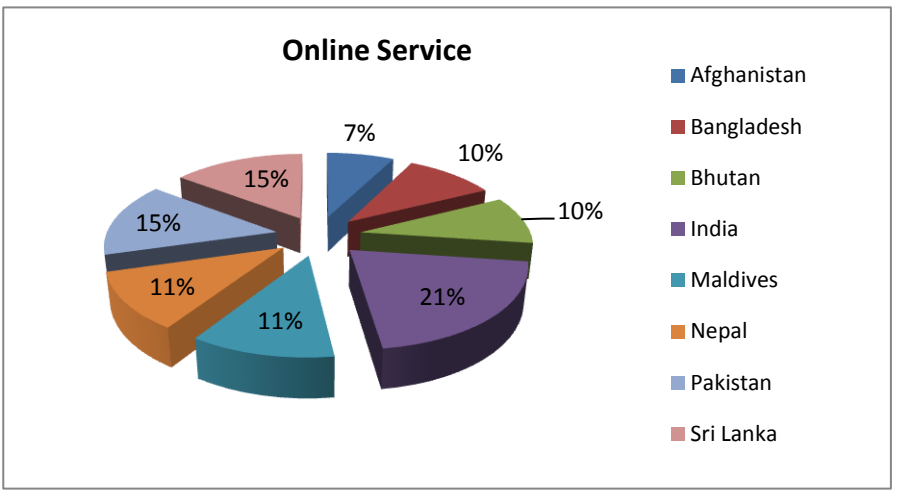


Figure 5: Fixed broadband subscription

The Figure 5 displays fixed broadband subscription in South Asia. This indicator is also showing low performance. Except Maldives and Bhutan, all countries are ranked less than 1 on this indicator of ICT.



Figures 6: Share of individual country in averaged regional online service index

The Figure 6 presents the share of each country in averaged regional online service index. The Figure shows that India and Pakistan are performing the best on this index. In contrast, Afghanistan is ranked the lowest on this index. Bhutan, Bangladesh and Nepal have similar shares.

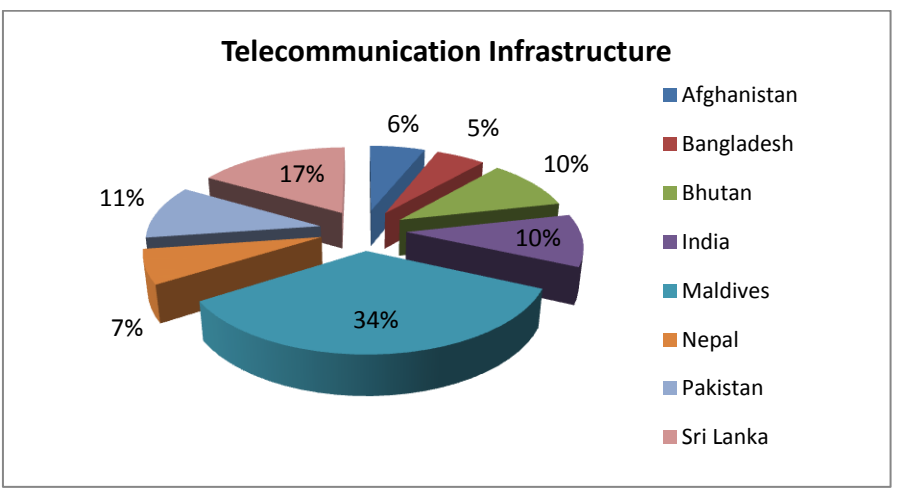


Figure 7: Share of individual country in averaged regional telecommunication infrastructure

The Figure 7 presents the share of individual country in averaged regional telecommunication infrastructure. It shows that Maldives and Sri Lank are performing the best on this index. In contrast, Afghanistan and Bangladesh are ranked the lowest on this index.

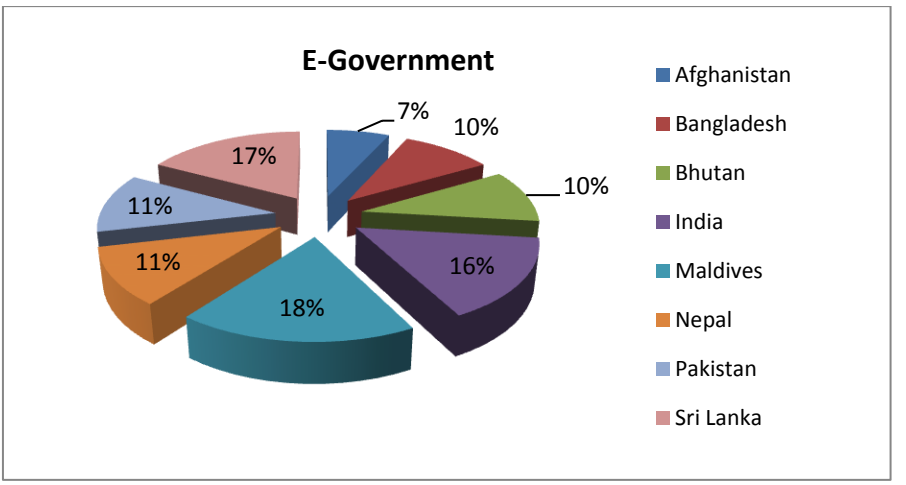


Figure 8: Share of individual country in E-government

Lastly, the Figure 8 shows the share of each country in implementation of e-government in South Asia over the study period. The Figure shows that Maldives and India are leading countries for the adoption of e-government while Afghanistan and Bangladesh are the most lagging countries.

Results

The empirical analysis has been conducted employing alternative techniques of econometrics such as Pooled OLS (POLS), Fixed Effects Model (FEM), Random Effects Model (REM), Two Stage Least Squares (2SLS) and Generalized Method of Moments (GMM) estimation techniques. Since ICT measures are highly correlated with each other, their empirical effects are determined separately.

The base line results using POLS method of estimation are presented in Table 1. The column (1) shows that the coefficient on mobile phone subscriptions (MPS) is positive and highly significant. It implies that one percent increase in the users of mobile phones produces 0.133 percent expansion in per capita income. This finding is consistent with the findings of Aker and Mbiti (2010). The usage of mobile phones helps to overcome asymmetric information in market transactions. Moreover, increasing usage of mobile phones facilitates exploration and excess to the world markets for exports of developing economies (Majeed & Ahmad, 2006).

Table 1: ICT, E-Government and Economic Growth-POLS Estimation

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Labor	0.978*	0.995*	1.020*	0.956*	0.941*	0.901*	0.941*	0.932*
	(0.028)	(0.025)	(0.019)	(0.027)	(0.041)	(0.045)	(0.036)	(0.031)
Capital	0.914*	0.983*	0.690*	0.586*	0.276	0.376	0.419	0.265
	(0.208)	(0.193)	(0.151)	(0.209)	(0.298)	(0.274)	(0.260)	(0.250)
HK	0.941*	1.109*	0.576*	0.855*	0.837*	0.847*	0.448**	0.692*
	(0.086)	(0.074)	(0.075)	(0.091)	(0.204)	(0.148)	(0.222)	(0.129)
INF	-0.312*	-0.303*	-0.111*	-0.291*	-0.276	-0.248*	-0.103	-0.191*
	(0.055)	(0.053)	(0.037)	(0.061)	(0.176)	(0.079)	(0.124)	(0.073)
MPS	0.133*							
	(0.026)							
IU		0.052*						
		(0.015)						
FTS			0.397*					
			(0.031)					
FBS				0.082*				
				(0.025)				
TCI					0.912			
					(0.606)			
OSI						1.294**		
						(0.544)		
E-gov.							2.814*	
							(0.863)	
ICT								0.293*
								(0.096)
Constant	-3.042*	-3.169*	-4.171*	-2.994*	-3.999*	-3.445*	-3.977*	-3.322*
	(0.700)	(0.655)	(0.496)	(0.728)	(1.031)	(1.026)	(0.939)	(0.775)
Obs.	88	130	154	75	90	90	90	136
R-squared	0.943	0.928	0.951	0.951	0.947	0.951	0.956	0.951

Standard errors in parentheses
* p<0.01, ** p<0.05, *** p<0.1

Column (2) presents another indicator of ICT that is the number of internet users (IU) per 100 people. The column (2) also shows that one percent increase in internet users generates 0.052 percent GDP per capita growth rate. It suggests that internet influences economic growth of South Asian countries positively and significantly. This finding is consistent with Choi and Hoon-Yi (2009). The use of internet helps to remove imperfections of market information and it also reduces transaction costs. Likewise, the increasing use of e-services such as e-ticket, e-finance and e-commerce enhances the efficiency in the market and improves economic growth rates. Furthermore, the increasing use of internet improves the productivity of the labor force through improving their health outcomes (Majeed & Khan, 2019).

Columns (3) and (4) present the parameter estimate on fixed telephone subscriptions (FTS) and fixed broadband subscriptions (FBS), respectively. The parameter estimates of both indicators have positive and significant impact on economic growth of South Asian countries. These indicators show that one percent increase in FTS and FBS causes 0.397 and 0.082 percent increase in economic growth, respectively. It implies that the effect of FTS is stronger than the effect of FBS. Since the facility of phone is more easily managed as compared to broadband, it is causing more impact (Aker & Mbiti, 2010; Choi & Hoon-Yi, 2009; Vu, 2011).

Column (5) reports the results obtained using telecommunication infrastructure index (TCI) as a measure of ICT. This indicator also causes positive but insignificant effect on economic growth of South Asian countries. The positive association of telecommunication infrastructure with economic growth is consistent with Kaur & Malhotra (2014). Telecommunication infra-structure is an important source of network externalities which boosts economic performance. South Asian region perhaps stands lower at this index and, therefore, its significance level is not achieved in the region.

Column (6) presents results using online service index (OSI) as a measure of ICT. This indicator significantly and positively supports ICT-growth nexus in the region of South Asia. The Table 1 shows that OSI positively affects GDP per capita of South Asian countries. The OSI indicator stands strong as compared to other indicators of ICT implying that adaption of OSI in South Asia can serve as a strong driver of regional growth.

Column (7) presents the result of e-government index. It is evident form its coefficient that one percent increase in its index will produce 2.81 percent increase in GDP per capita of South Asia. The adoption of e-government is considered a potential source of controlling corruption and enhancing growth process of a developing economy. Ma et al. (2005) highlighted the importance of e-government. The study argues that e-government facilities growth process by controlling corruption and facilitating financial development and trade in a country. There are different channels through which e-government facilitates

economic growth. For instance, e-government improves the quality of services of public sector, strengthens the role of democracy and encourages trustworthiness in the society by ensuring transpareny (West, 2004; Von-Haldenwang, 2004; Krishnan & Teo, 2012).

Finally, to assess the overall effect of ICT, an index is constructed using Principal Component Index. The results of ICT index are reported in the last column (8) of Table 1. The parameter estimate on ICT index suggests that overall ICT development is a potential source of growth in the region of South Asia. The positive effect of ICT is significant and it indicates that one percent increase in ICT in South Asia causes 0.293 percent increase in economic growth (Summers, 1999).

Regarding control variables our results are similar to earlier studies on economic growth. The effect of input variables labor and capital is positive and significant in almost all regression. Similarly, the impact of human capital (*HK*) is positive and significant (Barro, 1998; Mankiw et al., 1992; Chaudhary & Khan, 2002). Khan and Majeed (2018) also suggest that poor people with proper learning skills are in a better position to take the advantage of new growth opportunities. However, the growth effect of inflation (*INF*) is negatively significant (Majeed and Malik, 2016). It is an indicator of macroeconomic instability which adversely affects economic performance of a country.

The region of South Asia comprises diverse combination of the countries. There could be a bias due to country specific omitted variables. To address such bias, we introduce fixed effects estimation approach. The fixed effects estimation approach is considered superior to OLS as it controls country specific time invariant characteristics. In addition, FEM captures unobserved heterogeneity by estimating intercept for each cross sectional unit in the panel data. The results obtained using fixed effects methods are reported in Table 2.

Table 2: ICT, E-Government and Economic Growth-Fixed Effects Estimation

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Labor	0.235	0.383*	0.420*	-0.254	0.679***	1.299*	1.261*	1.217*
	(0.265)	(0.105)	(0.138)	(0.333)	(0.353)	(0.334)	(0.334)	(0.328)
Capital	0.357*	0.541*	0.496*	0.349*	0.321***	0.503**	0.468**	0.481*
	(0.101)	(0.090)	(0.067)	(0.093)	(0.172)	(0.193)	(0.190)	(0.115)
HK	0.511**	1.057*	1.347*	0.706*	0.995*	1.303*	1.263*	1.265*
	(0.237)	(0.242)	(0.158)	(0.236)	(0.324)	(0.356)	(0.354)	(0.363)
INF	-0.019	-0.002	-0.013	-0.011	-0.011	-0.088	-0.078	0.018
	(0.021)	(0.019)	(0.014)	(0.017)	(0.048)	(0.052)	(0.049)	(0.027)

MPS	0.068*							
	(0.015)							
IU		0.035*						
		(0.009)						
FTS			0.105*					
			(0.017)					
FBS				0.0772*				
				(0.011)				
TCI					1.547*			
					(0.493)			
OSI						0.0183		
						(0.184)		
E-gov.							0.370	
							(0.485)	
ICT								0.074
								(0.058)
Constant	6.326	2.195	0.993	14.57*	-2.263	-13.66*	-12.97**	-12.24*
	(4.486)	(3.280)	(2.121)	(5.683)	(5.847)	(5.241)	(5.249)	(4.311)
Obs.	88	130	154	75	90	90	90	136
R-squared	0.826	0.879	0.925	0.833	0.812	0.756	0.760	0.713
No. of id	8	8	8	8	8	8	8	8

Standard errors in parentheses
* p<0.01, ** p<0.05, *** p<0.1

Table 2 shows that baseline findings remain similar though marginal effects slightly fluctuate when fixed effects model has been estimated. Regarding control variables, the study finds that all control variables have same impact as discussed earlier.

The countries in South Asia face certain country specific random shocks. There could be a bias due to country specific random shocks. However, fixed effects estimation approach does not control the effects of random shocks in error terms. In addition, FEM may worsen the problem of multicollinearity due to dummy variables trap. To address such bias, we introduce random effects estimation approach. The results obtained using random effects methods are reported in Table 3.

Table 3: ICT, E-Government and Economic Growth-Random Effects Estimation

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Labor	0.787*	0.726*	0.706*	0.841*	0.841*	0.900*	0.907*	0.827*
	(0.059)	(0.089)	(0.079)	(0.031)	(0.052)	(0.118)	(0.119)	(0.033)
Capital	0.383*	0.556*	0.512*	0.0833	0.312**	0.505*	0.463**	0.324**
	(0.109)	(0.091)	(0.069)	(0.181)	(0.152)	(0.190)	(0.185)	(0.161)
HK	0.764*	0.858*	1.061*	0.890*	0.670*	1.436*	1.351*	0.750*
	(0.189)	(0.187)	(0.114)	(0.113)	(0.215)	(0.249)	(0.259)	(0.150)
INF	-0.016	-0.007	-0.016	-0.062	-0.018	-0.076	-0.066	0.007
	(0.021)	(0.019)	(0.014)	(0.041)	(0.049)	(0.051)	(0.048)	(0.046)
MPS	0.038*							
	(0.011)							
IU		0.029*						
		(0.008)						
FTS			0.103*					
			(0.017)					
FBS				0.059*				
				(0.014)				
TCI					1.632*			
					(0.406)			
OSI						0.056		
						(0.182)		
E-gov.							0.523	
							(0.468)	
ICT								0.259*
								(0.077)
Constant	-3.653*	-3.314**	-3.382*	-3.613*	-4.262*	-7.125*	-7.131*	-3.874*
	(1.097)	(1.472)	(1.210)	(0.769)	(1.123)	(1.999)	(1.987)	(0.812)
Obs.	88	130	154	75	90	90	90	136
No. of id	8	8	8	8	8	8	8	8

Standard errors in parentheses
* p<0.01, ** p<0.05, *** p<0.1

The Table 3 provides similar findings and confirms that different components of ICT and e-government positively affect economic growth in South Asian region. Although marginal effects are slightly different, yet the base line findings remain consistent even with random effects estimation.

There is possibility of endogeneity because of omitted variable biases, measurement error and reverse causality. The POLS estimates become inefficient and biased in the presence of endogeneity, therefore, to deal with the potential problem of endogeneity and heteroscedasticity, the study applies Two Stage Least Squares (2SLS) and Generalized Method of Moments (GMM) by introducing own lag variables and two instruments of personal computer and telecommunication revenue. The results obtained using 2SLS are given in Table 4.

Table 4: ICT, E-Government and Economic Growth-2SLS Estimation

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Labor	0.997*	1.011*	1.031*	0.971*	0.890*	0.845*	0.887*	0.941*
	(0.028)	(0.026)	(0.021)	(0.028)	(0.069)	(0.056)	(0.052)	(0.0293)
Capital	0.827*	0.902*	0.696*	0.539*	0.308	0.195	0.325	0.352
	(0.192)	(0.183)	(0.147)	(0.198)	(0.647)	(0.459)	(0.473)	(0.249)
HK	0.938*	1.119*	0.587*	0.834*	0.821**	0.801*	0.420	0.756*
	(0.082)	(0.073)	(0.075)	(0.095)	(0.371)	(0.170)	(0.317)	(0.145)
INF	-0.339*	-0.301*	-0.105*	-0.270*	-0.478	-0.432**	-0.194	-0.241*
	(0.051)	(0.051)	(0.036)	(0.061)	(0.447)	(0.195)	(0.285)	(0.089)
MPS	0.150*							
	(0.027)							
IU		0.064*						
		(0.017)						
FTS			0.401*					
			(0.031)					
FBS				0.094*				
				(0.029)				
TCI					0.745			
					(1.607)			
OSI						1.515**		
						(0.680)		

E-gov.							2.911**	
							(1.394)	
ICT								0.213***
								(0.117)
Constant	-3.665*	-3.744*	-4.372*	-3.408*	-2.712	-2.85**	-3.239*	-3.306*
	(0.673)	(0.643)	(0.495)	(0.725)	(2.014)	(1.430)	(1.156)	(0.736)
Obs.	81	122	153	67	88	88	88	134
R-squared	0.947	0.932	0.949	0.951	0.960	0.972	0.969	0.952

Standard errors in parentheses
* p<0.01, ** p<0.05, *** p<0.1

This method gives better results as compared to the previous estimation techniques as all indicators are causing positive and significant effect on economic growth of South Asia. The effect of e-government is comparatively stronger implying that this region can significantly benefit from the implementation of ICT infrastructure in public sector.

Table 4 also shows that all other control variables except inflation are causing positive impact on economic growth of South Asian economies. This negative impact of inflation is also consistent with the empirical literature.

Stanley et al. (2018) find that countries with higher GDP per capita are more efficient in making investment in new technologies. This finding suggests that there is possibility of reverse causality between economic growth and ICT in our sample. In addition, there is heterogeneity issue for panel data set. To handle these issues, the study uses the GMM estimation technique. The GMM method gives more efficient results even in the presence of endogeneity and heterogeneity. Finally, the study reports results obtained using Generalized Method of Moments (GMM) in Table 5.

The baseline findings remain similar in this estimation as well. The relative strength of e-government as compared to other measures of ICT further increases in this estimation technique. Table 5 shows that 1 percent increase in the index of e-government causes 3.34 percent increase in GDP per capita growth of South Asia. It suggests that e-government has positive impact on per capita income of South Asian economies. It implies that development of e-government may promote economic growth in these countries. Because e-government facilitates e-financing that cut down information cost, shoe-leather and the data processing costs (Majeed & Malik, 2016).

Table 5 shows that labor force, physical capital and human capital have positive and significant impacts on economic growth while inflation rate has negative impact on GDP per capita in South Asian region.

Table 5: ICT, E-Government and Economic Growth-GMM Estimation

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Labor	1.046*	1.068*	1.047*	1.019*	0.890*	0.842*	0.882*	0.962*
	(0.051)	(0.053)	(0.034)	(0.046)	(0.064)	(0.033)	(0.026)	(0.041)
Capital	1.065*	1.184*	0.789*	0.674*	0.308	0.195	0.375	0.496**
	(0.263)	(0.292)	(0.200)	(0.251)	(0.666)	(0.453)	(0.417)	(0.244)
HK	1.050*	1.250*	0.646*	0.918*	0.821**	0.786*	0.300	0.745*
	(0.120)	(0.131)	(0.123)	(0.131)	(0.375)	(0.176)	(0.260)	(0.171)
INF	-0.341*	-0.291*	-0.102*	-0.272*	-0.478	-0.434*	-0.107	-0.22**
	(0.064)	(0.061)	(0.037)	(0.071)	(0.35)	(0.123)	(0.195)	(0.092)
MPS	0.133*							
	(0.025)							
IU		0.052*						
		(0.019)						
FTS			0.386*					
			(0.032)					
FBS				0.101*				
				(0.024)				
TCI					0.745			
					(1.203)			
OSI						1.502*		
						(0.392)		
E-gov.							3.334*	
							(0.811)	
ICT								0.245**
								(0.117)
Constant	-3.95*	-4.149*	-4.467*	-4.001*	-2.711	-2.762	-3.002**	-3.183*
	(0.756)	(0.822)	(0.565)	(0.816)	(2.069)	(1.700)	(1.452)	(0.761)
Obs.	81	122	153	67	88	88	88	136
R-squared	0.943	0.927	0.949	0.949	0.960	0.972	0.968	0.951

Robust standard errors in parentheses
* p<0.01, ** p<0.05, *** p<0.1

It is also evident from our results that human capital is a strong determinant of economic growth in South Asian countries. It is an important finding as it suggests that investment in human capital can offset the loss of employment created by the adoption of e-government.

All these findings suggest that South Asian economies can significantly benefit from investment in ICT infrastructure in general and its implementation in public sector in particular.

Conclusion

The study investigates growth effects of ICT and e-government in the context of macroeconomic growth model for a sample of eight South Asian economies over the period 1980-2016. The study estimates growth model with Pooled OLS, Fixed Effects, Random Effects, Two Stage Least Squares and Generalized Method of Moments econometrics techniques.

The present study contributes into the existing literature on economic growth and ICT by using diverse measures of ICT to capture the more robust parameter estimates. In particular, to untangle the growth effects of information and communication technology in public sector, a unique measure of e-government has been introduced. Moreover, to address the potential problem of endogeneity, instrumental variables estimation technique has been used.

The results show that all measures of ICT and e-government have positive as well as significant impact on economic growth of South Asian economies. The parameter estimates across ICT measures slightly fluctuate where the marginal impact of internet users is comparatively lower while the marginal impact of phones is comparatively higher. A Principal Component Analysis of ICT measures shows that one percent increase in ICT causes 0.24 percentage point increase in growth. Our results illustrate that positive impact of e-government is strong in the region. The coefficient of e-government shows that 1 percent increase in the index of e-government causes 3.33 percent increase in GDP per capita growth of South Asian economies.

In the lights of above findings we can conclude that ICT and e-government are exclusively contributing in the economic growth of South Asian economies. Findings of the study suggest that South Asian countries need to strengthen their ICT policies to improve the use of new information and communication technology and engage skilled workers. Moreover, findings on e-government suggest that South Asian countries need to reinforce implementation of ICT in public sector. On the other side, inflation should be contained in the long-term to avoid its negative impact on growth.

This study has certain limitations. First, the data for e-government is limited in the case of South Asian countries. Second, panel time series analysis is not conducted. Future research can extend this analysis for other regions to have a

comparative analysis across regions using panel time series analysis. Moreover, this analysis can be extended for a comparative global analysis.

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