Theoretical and Applied Economics
Volume XXXI (2024), No. 2(639), Summer, pp. 289-302

ICT and economic growth: Evidence from lower-middle income countries of South Asia

Kirti SANWAL
Jamia Millia Islamia, New Delhi, India
kirtisanwal.2797@gmail.com
Saba ISMAIL
Jamia Millia Islamia, New Delhi, India
sismail@jmi.ac.in

Abstract. *The present study examines the impact of information and communication technology (ICT) on the economic growth of the lower-middle income countries of South Asia. For empirical analysis, panel data approach comprising OLS, fixed effects, and random effects has been applied over the period 2000-2022. The results indicate that internet and mobile penetration induce economic growth in the lower-middle income countries of South Asia, while the estimated output elasticity for internet is highest amongst the three ICT indicators undertaken in the study. Thus, internet can be used as a growth propellant in the region to skip through the developmental stages.*

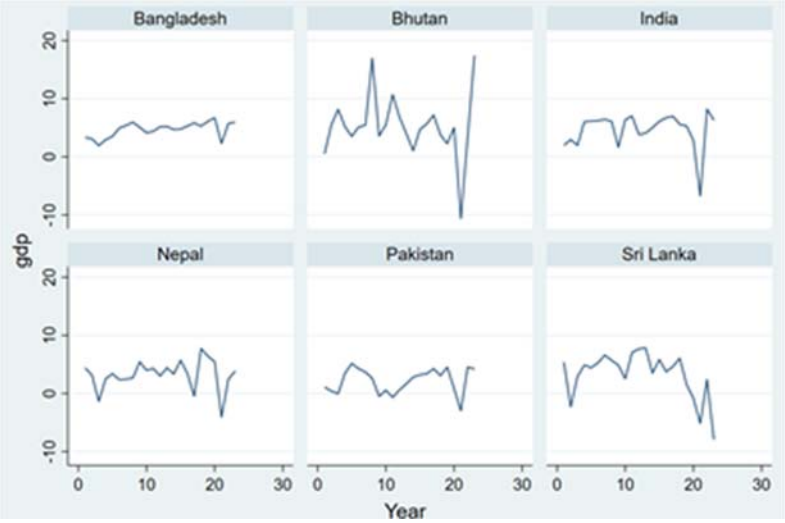
Keywords: ICT, economic growth, South Asia, panel data analysis, growth accounting.

JEL Classification: O4, O47.

1. Introduction

South Asian region is a peculiar case with dual characteristics, on one hand it is the second fastest growing region of the world but on the other it is home to more than 33% of the world's poor with low socio-economic indicators. Majority of this region comprises lower-middle income countries such as Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka, which besides having similar cultural and historical ties, suffer from similar challenges such as economic and political instability, high inflation and debt ratios. Figure 1 shows the trend of growth rate profiles of individual countries in the region. It is observed that a downward trend is observed specifically post 2020 which can be attributed to the Covid-19 crisis, wherein the cumulative growth rate of the countries was restricted at the rate of -10%. A prominent fact is that this region has observed rapid growth in information and communication technology sector post the globalization era with coming of mobile telephony usage and later internet penetration post the beginning of the 21st century (UN-ESCAP, 2019). ICT is considered to include any communication device such as mobile phones or computers and other applications such as Internet and Broadband, according to the Global Competitive Report (2016-17).

Figure 1. *Growth profile of selected South Asian countries*



Source: Authors' own representation using WDI database.

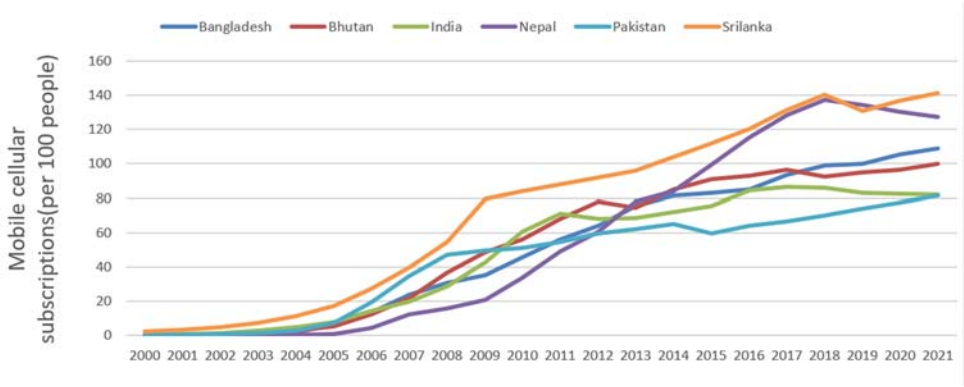
Importance of ICT infrastructure can be well emphasized by the Target 9.c of the SDG 9 which states to "Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2030" (Goal 9, Sustainable Development Agenda 2030). Owing to the importance of information and communication technology in contemporary times, literature has documented the relationship among ICT and various other variables like

sustainable development (Latif et al, 2017), financial inclusion (Mushtaq and Bruneau, 2019), income gap (Ahmad et al.,2022), poverty (Olamide et al.,2022), productivity (Jung and Bazo,2020) and foreign direct investment (Bhujabal and Sethi, 2019). Mushtaq and Bruneau (2019) collected the data for sixty- two countries across the globe for the period 2001-12 to explore the interlinkages among ICT infrastructure, poverty and inequality through financial inclusion channel. GMM regression modelling is employed to conclude that mobile phones, internet and telephones are significant in reducing poverty even after controlling for inflation, government consumption expenditure and trade openness. A recent study by Behera et al. (2023) examined how the effect of financial development along with other variables such as FDI, institutional quality and innovation is modulated by ICT for selected emerging economies.

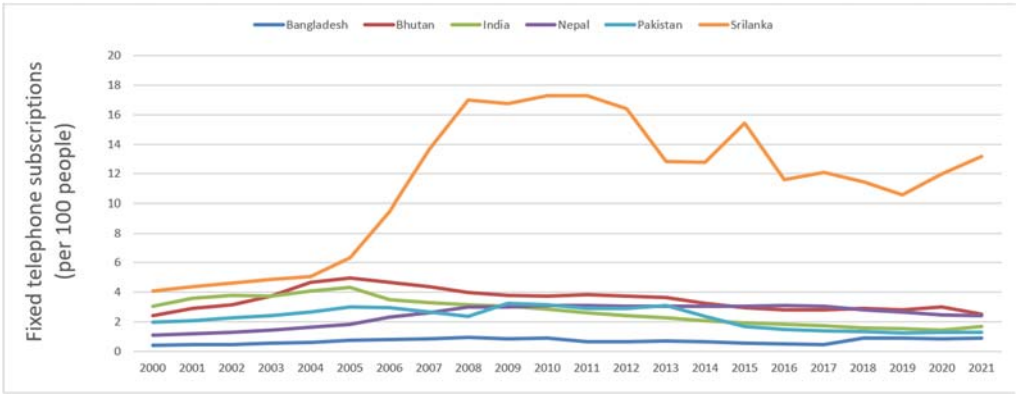
South Asian region is focusing on ICT in the past few years, in order to bypass the traditional stages of development and enhance its growth possibilities. (Hussain et al.,2021). The trends of the measures of ICT (% of Individuals using internet, mobile cellular subscriptions and fixed telephone subscriptions) considered in the study are displayed in Figure 2. Increasing trend is observed over the years for internet and mobile penetration but a constant or decreasing trend is observed for telephone density in the South Asian countries.

The remainder of the paper is organized as follows: Section 2 presents a brief review of literature. Section 3 focuses on the methodology applied. Section 4 discusses the results found. Section 5 deals with the conclusion and policy implications.

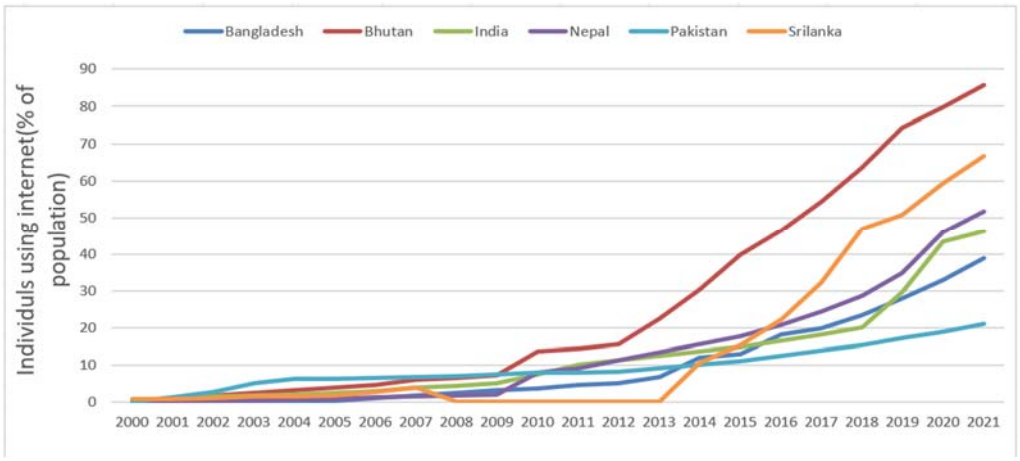
Figure 2. *Trend of ICT indicators in selected South Asian nations*



Source*:* Authors' own representation using WDI database.



Source: Authors' own representation using WDI database.



Source: Authors' own representation using WDI database.

2. Review of Literature

The underpinnings of the neo-classical growth theory (Solow,1956), the neo-Schumpeterian theory (Schumpeter, 1934) and the Endogenous growth theory (Romer, 1990) have highlighted the favourable effects of technological progress on economic growth. As per International Telecommunication Union, the past two decades initiating from 2000 has observed increasing growth of the telecommunication sector in the form of increased investments and increasing demand for telecom services, which has incentivized researchers across the globe to examine the ICT and growth nexus.

More recently, Pradhan et al. (2022) employed ARDL bounds and Granger causality approach, and examined the causal relationship between ICT infrastructure and economic

growth both in the long and short run for G-20 countries spanning the time period 1961-2019. ICT is measured by considering six indicators, namely telephone landlines, mobile, internet users, internet servers, broadband, and a composite index of ICT computed using principal component analysis. The results show that ICT infrastructure and economic growth exhibit long run relationship for most of the G-20 countries. Further, applying VECM estimation techniques, the study reports supply-lending hypothesis i.e. ICT causes economic growth in the long run while demand-following hypothesis i.e. economic growth causes ICT, follows in the short run for most of the cases. In another study, both long and short run relationship has been found between ICT (broadband and internet) and economic growth for G-20 countries using the VECM analysis (Pradhan et al.,2018).

Pradhan et al. (2013) carried out a study on OECD countries for the period 1990 to 2010, in order to examine the nexus between Internet users and economic growth using panel cointegration and error correction models. The results indicate that economic growth along with other macroeconomic variables like inflation and government expenditure determine internet penetration in the long run. Another extensive study by Myovella et al. (2019) utilize a balanced panel data set of 41 Sub-Saharan Africa (SSA) and 33 OECD countries to compare the effects of telecommunications infrastructure, which was one of the major aspects of digitalization. Both static and dynamic panel data techniques such as OLS, fixed effect and system GMM are employed to both the samples. The findings of the study are indicative of the fact that mobile technologies are more prominent in determining the economic growth of under-developed regions i.e. SSA, rather than in the developed OECD economies. But internet actively fosters economic prosperity in both the regions, though SSA is found to have minimal usage of internet owing to affordability constraints. Another comparative study on the same lines was conducted by Bahrini and Qaffas (2019) who used a two-step panel generalized method of moments (GMM) model for 45 developing countries in the Middle East and North African (MENA) and Sub-Saharan Africa (SSA) regions over the period 2007-2016; they found that internet users and broadband adoption had a significant positive impact on economic growth in both the regions while mobile phones had a positive but significant impact in MENA region only. On the other hand, fixed telephone lines had a negative and statistically significant impact on economic growth of both the regions. The authors have accounted the substitution of telephone lines by mobile phones in many developing countries as one of the reasons for the above result.

Pradhan et al. (2015) is one of the extensive studies which explores the dynamic linkages between ICT infrastructure, Financial Development and economic growth for 21 Asian countries divided regionally into East Asia, South Asia, South-East Asia and West Asia over the period 2001-2012. ICT and financial development indices are created using PCA and panel cointegration and error-correction models (ECM) are employed to ascertain the long run and short run causal relationship between the three study variables. The study finds for the South Asian region, that both ICT and Financial Development induce

economic growth in the short run but not in the long run. Conducting regional analysis by taking sub samples from the African region, Adeleye and Eboagu (2019) is one of the exhaustive studies taking into consideration five sub-regions of Africa comprising 54 countries over the period 2005-15. The study employs static and dynamic panel data techniques such as pooled OLS, fixed and random effects, and system generalized methods of moments by establishing a neo-classical model. The study was able to prove the leapfrogging hypothesis of ICT i.e. ICT can skip through the developmental stages. Amongst the three indicators; fixed telephone lines, mobile phone subscriptions and internet users, it was found that mobile phone possess the most leapfrogging potential through the developmental stages in all the three model specifications.

There is also evidence for comparative studies based on different income levels, one of the recent ones being a study by Appiah and Song (2021) who studied the impact of ICT infrastructure on the economic growth of 123 countries by diving them into high income, middle-income and low- income countries over the period 2002-2017. Using the aggregate production function of Solow (1956), the study employs IV-GMM model to address the endogeneity and heteroscedasticity problems. Further, PCA is used to create composite index of ICT using mobile, internet and broadband indicators. The study finds that all the three indicators lead to enhancing growth outcomes for all the sets of countries. Besides that, poor countries gain more from the increased ICT penetration. Kurniawati (2021) is a similar study which uses panel data for 2000-18 in 25 Asian countries divided as per different income groups. The study make use of 3 ICT indicators-internet users, telephone lines and mobile phone subscriptions. On one hand, internet users are more significant in determining economic growth in high-income countries while it is the telephone and mobile subscribers which have more growth promoting effects in middle-income countries.

On studies related to South Asia, Bhujabal and Sethi (2019) tried to find the dynamic relationship between FDI, trade, ICT and economic growth in SAARC nations. The study found out long run cointegrating relationship among the variables and presence of feedback effect between ICT and trade, while unidirectional causality was found running from FDI to trade. Tripathi and Inani (2020) assessed the impact of ICT on economic growth in a study of four SAARC nations during the years of 1990-2014. Production function approach and pooled OLS, fixed and random effect techniques are applied. But a major limitation of this study lies in the fact that Tele density (Telephone and Mobile subscribers) is used as a proxy for ICT. Internet penetration which is one of the important aspects in ICT, is not considered as an indicator for measuring ICT. Usman et al. (2018) is another study for the four SAARC nations with the same limitation. The present study intends to fill the gap in the literature by addressing the six lower- middle income countries of South Asia.

3. Data and Model

3.1. Data

Annual data ranging from 2000 to 2022 for the six lower- middle income countries of South Asia (Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka) were obtained from World Development Indicators (WDI) of World Bank and ILO. The reason for limiting the time frame is that before 2000s there was minimal or no penetration of ICT such as mobile phones, computers and internet in most of the developing countries due to which we report missing values for ICT indicators. Table 1 below lists the variables used in the paper. Economic growth would be considered as a dependent variable while internet penetration, mobile and telephone subscriptions are used as indicators of ICT which are our explanatory variables along with other variables like capital, labour and trade openness.

Table 1. *Description of variables*

Variable	Label	Source
Economic growth (GDP per capita growth; annual %)	Growth	WDI
Gross capital formation (% of GDP)	Capital	WDI
Labour Force participation rate (age 15+)	Labour	ILO
Trade (% of GDP)	Trade	WDI
Individuals using internet (% of population)	Internet	WDI
Mobile cellular subscriptions (per 100 people)	Mobile	WDI
Fixed Telephone subscriptions (per 100 people)	Tele	WDI

3.2. Model Specification

The study is based on the aggregate production function approach as given by Solow (1956). Studies like Adeleye and Eboagu (2019), Appiah and Song (2019) and Hussain et al. (2021) have used the same theoretical framework.

$$Y_{it} = f(K_{it}, L_{it}, ICT_{it}) \quad (1)$$

where Y_{it} is representative of the level of output in the economy, K_{it} shows capital, L_{it} shows the labour while ICT_{it} is indicative of technology.

$$Y_{it} = \alpha_0 + \alpha_1 K_{it} + \alpha_2 L_{it} + \alpha_3 ICT_{it} + \varepsilon_{it} \quad (2)$$

Taking log on both sides, the equation becomes

$$\ln Y_{it} = \alpha_0 + \alpha_1 \ln K_{it} + \alpha_2 \ln L_{it} + \alpha_3 \ln ICT_{it} + \varepsilon_{it} \quad (3)$$

ICT infrastructure is further expressed using three indicators of internet, mobile and telephone.

3.3. Methodology

The purpose of the study is to analyze the impact of ICT on economic growth in the lower-middle income countries of South Asia over the period 2000-2022. For that, the study uses ordinary least square estimation and panel modelling techniques such as fixed and random

effects model. ICT is characterized using three indicators i.e. individuals using internet (% of population), mobile cellular subscriptions (per 100 people), fixed telephone subscriptions (per 100 people). Stata software would be used to carry out the analysis.

Equation 1: $log\ \text{Growth}_{it} = \alpha_0 + \alpha_1\ log\ INTERNET + \alpha_2\ log\ \text{Capital}_{it} + \alpha_3\ log\ \text{Labour}_{it} + \alpha_4\ log\ Trade + \varepsilon_{it}$

Equation 2: $log\ \text{Growth}_{it} = \alpha_0 + \alpha_1\ log\ MOBILE + \alpha_2\ log\ \text{Capital}_{it} + \alpha_3\ log\ \text{Labour}_{it} + \alpha_4\ log\ Trade + \varepsilon_{it}$

Equation 3: $log\ \text{Growth}_{it} = \alpha_0 + \alpha_1\ log\ TELE + \alpha_2\ log\ \text{Capital}_{it} + \alpha_3\ log\ \text{Labour}_{it} + \alpha_4\ log\ Trade + \varepsilon_{it}$

All the above three equations would be run with pooled OLS (without considering fixed and random effects) and then with panel regressions specifications of fixed effect and random effect. Hausman (1978) test with the null hypothesis random effects model is more appropriate than the fixed effect would be applied to decide which of the above two models is more appropriate in the three growth accounting equations that have been established.

4. Empirical results and discussions

Table 2 shows summary of descriptive statistics of the study variables. Considering the ICT variables undertaken in the study, we observe that the average value of internet, mobile, telephone is 1.854, 3.008 and 0.916 respectively. Out of three indicators, mobile has the highest maximum value of 4.96 followed by internet at 4.51.

Table 2. *Descriptive Statistics*

Variable	Observation	Mean	Std. deviation	Min	Max
LogGrowth	138	1.337	0.625	−0.912	2.858
LogInternet	138	1.854	1.616	−2.644	4.519
LogMobile	138	3.008	2.307	−7.378	4.963
LogTele	138	0.916	0.927	−1.831	2.851
LogLabour	138	3.970	0.153	3.680	4.248
LogCapital	138	2.169	0.856	−1.335	4.010
LogTrade	138	3.844	0.410	3.206	4.758

Source: Authors' own estimation.

Table 3 displays the pairwise correlation between the study variables. It is evident that per capita GDP is positively related to all the explanatory variables including the three ICT indicators i.e. internet, mobile and telephone undertaken in the study. But the correlation coefficient came out to be significant for internet and mobile and not for telephone. Thus, deeper investigation is needed to ascertain the impact of specific ICT indicators on economic growth. Besides that, it can be observed that significant positive correlation of 81.50% exists between internet and mobile which is indicative of high degree of endogeneity among the explanatory variables. Thus, in order to avoid the multicollinearity

problem, separate regression equations considering different ICT indicators have been formulated as explained earlier in section 3.3.

Table 3. *Correlation matrix (at log level)*

	LogGrowth	LogInternet	LogMobile	LogTele	logLabour	logCapital	LogTrade
LogGrowth	1.000						
LogInternet	0.1739*	1.000					
LogMobile	0.2481*	0.8150*	1.000				
LogTele	0.0064	0.1782*	0.1528	1.000			
LogLabour	0.1396	-0.0171	-0.1041	-0.0136	1.000		
LogCapital	0.3846*	0.1951*	0.1538	0.1297	0.2412*	1.000	
LogTrade	0.3164*	0.1197	0.0068	0.4064*	0.4283*	0.3575*	1.000

***** at 5%level of significance.

Source: Authors' own estimation.

Cross-sectional dependence is one of the most common problems in macro panels which could make the results spurious. Thus, before conducting further analysis, it is important to examine whether cross sectional dependence exists or not. To check the same, Pesaran (2004) cross- sectional dependence test along with B-P/LM test of independence would be applied, both with the null hypothesis that residuals across entities are not correlated. The values of the test statistic and respective p-values are presented in Table 4. Both the tests confirm the acceptance of null hypothesis, and thus cross-sectional independence.

Table 4. *Cross-sectional dependence test results*

	PESARAN	B-P/LM
p-value	0.8279	0.1645
Test statistic	-0.217	20.197

Source: Authors' own estimation.

Table 5. *Panel unit root test results*

Variable	t-statistic	p-value
LogGrowth	-3.3949	0.0003
LogInternet	-2.812	0.0025
LogMobile	-4.580	0.00
LogTele	-1.90	0.0285
LogCapital	-4.0083	0.00
LogLabour	-1.6475	0.0497
LogTrade	-2.615	0.0044

Source: Authors' own estimation.

In the next step panel unit root test is employed in order to examine the stationarity of the variables. Taking the consideration of a balanced panel and cross-sectional independence in the data set, Levin-Lin-Chu (2002) test which is a first-generation panel unit root test, is an appropriate choice with the null hypothesis that all the panels contain a unit root. This test assumes that all the panels have mutual autoregressive parameters. Table 5 presents the stationary results for the dataset at level. It is evident that all the data series are integrated at the level, making the conditions apt for undergoing further econometric regression analysis.

Considering the internet-growth equation and then estimating the pooled OLS model i.e. without fixed and random effects (Model 1) followed by introducing the fixed effects called FEM afterwards (Model 2) and random effects called REM (Model 3), the result of the same is displayed in Table 6. It is observed that the coefficient of internet is 0.0351, 0.093 and 0.049 in OLS, FEM and REM respectively. Amongst the three, the coefficient of the FEM was statistically significant at 5%. Upon running the Hausman test it is confirmed that fixed effects model is more appropriate as chi-square value of 14.42 with a p-value of 0.0061 is obtained. Thus, as internet penetration increases by 1%, the per capita economic growth increases by 0.093%. So, internet as expected came out to be a critical determinant of GDP per capita. Estimated regression result also shows that the output elasticity of labour is negative in two of the three models. Unskilled labour and mass unemployment amongst the youth in developing countries is one of the major reasons that labour force is not a playing a catalytic role in the growth process.

Table 6. $log\ \text{Growth}_{it} = \alpha_0 + \alpha_1\ log\ INTERNET_{it} + \alpha_2\ log\ \text{Capital}_{it} + \alpha_3\ log\ \text{Labour}_{it} + \alpha_4\ log\ Trade_{it} + \varepsilon_{it}$

Dependent variable LogGrowth	OLS (Model 1)	FEM (Model 2)	REM (Model 3)
LogInternet	0.0351	0.093*	0.049
LogCapital	0.217***	0.163**	0.192
LogLabour	-0.079	1.831	-0.057**
LogTrade	0.316*	0.602*	0.366*
Constant	-0.991	-8.521	-0.352
Hausman Test Chi-square value p-value		14.42 (0.0061)	
F-test/ Wald-chi	7.96	7.66	27.07
Total observations	138	138	138

Note: * p<0.05; ** p<0.01; *** p<0.001. Besides that, Wald Chi is mentioned for REM estimation.
Where, Growth is represented by GDP per capita (annual %), Internet shows the % of individuals using internet, FEM and REM represent the fixed and random effects model respectively.

Source: Authors' own estimation.

Table 7. $log\ \text{Growth}_{it} = \alpha_0 + \alpha_1\ log\ MOBILE_{it} + \alpha_2\ log\ \text{Capital}_{it} + \alpha_3\ log\ \text{Labour}_{it} + \alpha_4\ log\ Trade_{it} + \varepsilon_{it}$

Dependent variable LogGrowth	OLS (Model 1)	FEM (Model 2)	REM (Model 3)
LogMobile	0.055**	0.069**	0.056**
LogCapital	0.201**	0.158**	0.180**
LogLabour	0.0082	1.705	0.075
LogTrade	0.328*	0.433	0.354*
Constant	-0.561	-7.50	-0.890
Hausman Test Chi-square value p-value		11.98 (0.0175)	
F-Test/ Wald-chi	9.66	8.00	32.51
Total observations	138	138	138

Note: * p<0.05; ** p<0.01; *** p<0.001. Besides that, Wald Chi is mentioned for REM estimation.
Where, Growth is represented by GDP per capita (annual %), Mobile shows Mobile cellular subscriptions (per 100 people), FEM and REM represent the fixed and random effects model respectively.

Source: Authors' own estimation.

Incorporating the second indicator of ICT infrastructure (Mobile) in the growth equation i.e. considering equation 2, the results are illustrated in Table 7 where it is evident that in all the three regression models, the coefficient of mobile is coming out to be positively significant at 1% level of significance. Employing the Hausman test for the choice between fixed effects and random effect model, a p-value of 0.0175 is obtained, which confirms that fixed effect model is more apt. The estimated output elasticity for mobile is 0.069% therefore, it can be said that a percentage change in mobile adoption can lead to 0.069% change in per capita GDP. Henceforth, we may not be wrong to conclude that mobile penetration is one of the essential determinants of per capita GDP in the lower-middle income countries of South Asia. It is also worth mentioning that capital formation in all the three models came out to be positively associated with output while examining the impact of mobile subscribers on output.

Table 8. $log\ \text{Growth}_{it} = \alpha_0 + \alpha_1\ log\ TELE_{it} + \alpha_2\ log\ \text{Capital}_{it} + \alpha_3\ log\ \text{Labour}_{it} + \alpha_4\ log\ Trade_{it} + \varepsilon_{it}$

Dependent variable (LogGrowth)	OLS (Model 1)	FEM (Model 2)	REM (Model 3)
LogTele	-0.104	-0.022*	-0.083
LogCapital	0.230***	0.195**	0.206***
LogLabour	-0.263	-0.586***	-0.288***
LogTrade	0.448**	0.544*	0.474*
Constant	0.254	1.515	0.283
Hausman Test Chi-square value p-value		4.86 (0.302)	
F-test/ Wald-chi	8.54	6.59	22.05
Total observations	138	138	138

Note: * p<0.05; ** p<0.01; *** p<0.001. Besides that, Wald Chi is mentioned for REM estimation.
Where, Growth is represented by GDP per capita (annual %), Tele shows Fixed telephone subscriptions (per 100 people), FEM and REM represent the fixed and random effects model respectively.

Source: Authors' own estimation.

Table 8 represents the impact of telephone density on the economic growth of South Asian countries. It is noted that in all the models viz a viz OLS, FEM and REM, a negative but insignificant influence is observed on the per capita growth. Performing the Hausman Test gives the case for applicability of random effects models instead of FEM**.** Summing up from the above results, it can be inferred that both internet and mobile positively influence the real per capita income but telephone negatively impacts it. One of the major reasons for this result observed in developing countries is the substitution of telephone lines by mobile phones in these countries (Bahrini and Qaffas ,2019). On the factors of production, the coefficient of capital is coming out to be positively and statistically significant for all the regression equations i.e. internet, mobile and telephone, as expected a priori. Thus, capital formation has synergistic effects with ICT indicators on the economic growth. The same has been corroborated by Adeleye and Ebaogu (2019) for the African nations, thus enabling capital formation as a growth determinant in the South Asian countries as well. Meanwhile,

labour has shown a positive but insignificant effect for internet and mobile regressions. The estimated elasticity for trade is positive for all equations, but only significant for internet and telephone.

A thorough analysis has got us to the conclusion that estimated output elasticity for internet is highest amongst the three ICT indicators undertaken in the study which indicates that accessibility of Internet is a major determinant of economic growth in the South Asian region. Thus, internet can be used as a growth propellant in the region to skip through the developmental stages. Studies like Vu and Asongu (2020) and Hussain et al., (2021) have also emphasized on the stimulating impact of internet penetration on per capita income, owing to the "Backwardness Advantage".

5. Conclusion and policy implications

The twenty-first century is a knowledge-led economy, making the role of information and communication technology important in the present scenario. This paper was in the same direction to analyze the impact of ICT indicators on South Asian countries economic growth. The results are indicative of the fact that both internet and mobile penetration induce growth in the lower-middle income countries of South Asia, though the growth stimulating impact of internet is more than that of mobile. Thus, policy makers should focus on increasing the accessibility of ICT among the masses to harness the potential of this sector in achieving the goals of rapid and sustained economic growth. ICT specifically internet can be used to "leapfrog" developmental stages in South Asian region. It's also worth mentioning that gross capital formation is a growth propellant while labour force participation rate has unfavorable effects on growth. Adeleye and Eboagu (2019) also reported the same but on the sample of African countries. Thus, policy intervention in the developing regions should include imparting the necessary skill set and training of the abundant workforce to enhance their productivity. Besides that, issues of unemployment and capital formation must take a front seat in regional groupings such as SAARC and BIMSTEC to induce economic growth in the region. Despite the above backdrop, the study is not free from limitations. Although the study has tried to incorporate the prominently used measures of ICT but it has not included the new age digital technologies such as internet of things, cloud computing, blockchain and robotics due to data constraints. Also, the study has considered the linear effects of ICT on economic growth. Future studies can focus on other lower-middle income of the developing regions so that generalized conclusions can be established for such regions.

References

Adeleye, N. and Eboagu, C., 2019. Evaluation of ICT development and economic growth in Africa. *NETNOMICS: Economic research and electronic networking*, *20*, pp. 31-53.

Ahmad, S., Khan, D. and Haq, I.U., 2022. Assessing the role of information and communication technology in reducing the gap between rich and poor: the case of South Asia. *International Journal of Social Economics*, *49*(11), pp. 1663-1679.

Appiah-Otoo, I. and Song, N., 2021. The impact of ICT on economic growth-Comparing rich and poor countries. *Telecommunications Policy*, *45*(2), p. 102082.

Bahrini, R. and Qaffas, A.A., 2019. Impact of information and communication technology on economic growth: Evidence from developing countries. *Economies*, *7*(1), p. 21.

Behera, B., Haldar, A. and Sethi, N., 2023. Investigating the direct and indirect effects of Information and Communication Technology on economic growth in the emerging economies: role of financial development, foreign direct investment, innovation, and institutional quality. *Information Technology for Development*, pp. 1-24.

Bhujabal, P. and Sethi, N., 2020. Foreign direct investment, information and communication technology, trade, and economic growth in the South Asian Association for Regional Cooperation countries: An empirical insight. *Journal of Public Affairs*, *20*(1), p. e2010.

Hausman, J.A., 1978. Specification tests in econometrics. *Econometrica: Journal of the econometric society*, pp. 1251-1271.

<https://www.unescap.org/publications/economic-and-social-survey-asia-and-pacific-2019-ambitions-beyond-growth>

<https://www3.weforum.org/docs/GCR2016-2017/05FullReport/TheGlobalCompetitivenessReport2016-2017_FINAL.pdf>

Hussain, A., Batool, I., Akbar, M. and Nazir, M., 2021. Is ICT an enduring driver of economic growth? Evidence from South Asian economies. *Telecommunications Policy*, *45*(8), p. 102202.

Jung, J. and López-Bazo, E., 2020. On the regional impact of broadband on productivity: The case of Brazil. *Telecommunications Policy*, *44*(1), p. 101826.

Kurniawati, M.A., 2021. Analysis of the impact of information communication technology on economic growth: empirical evidence from Asian countries. *Journal of Asian Business and Economic Studies*, *29*(1), pp. 2-18.

Latif, Z., Xin, W., Khan, D., Iqbal, K., Pathan, Z.H., Salam, S. and Jan, N., 2017. ICT and sustainable development in South Asian countries. *Human Systems Management*, *36*(4), pp. 353-362.

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

Mushtaq, R. and Bruneau, C., 2019. Microfinance, financial inclusion and ICT: Implications for poverty and inequality. *Technology in Society*, *59*, p. 101154.

Myovella, G., Karacuka, M. and Haucap, J., 2020. Digitalization and economic growth: A comparative analysis of Sub-Saharan Africa and OECD economies. *Telecommunications Policy*, *44*(2), p. 101856.

Olamide, E., Ogujiuba, K.K., Maredza, A. and Semosa, P., 2022. Poverty, ICT and economic growth in SADC region: A panel cointegration evaluation. *Sustainability*, *14*(15), p. 9091.

Pesaran, M.H., 2004. General diagnostic tests for cross section dependence in panels. Cambridge Working Papers. *Economics*, *1240*(1), p. 1.

Pradhan, R.P., Arvin, M.B. and Norman, N.R., 2015. The dynamics of information and communications technologies infrastructure, economic growth, and financial development: Evidence from Asian countries. *Technology in Society*, *42*, pp. 135-149.

Pradhan, R.P., Bele, S. and Pandey, S., 2013. More penetration, more growth? A panel cointegration analysis for the OECD countries. *International Journal of Public Policy*, *9*(4-5-6), pp. 371-388.

Pradhan, R.P., Mallik, G. and Bagchi, T.P., 2018. Information communication technology (ICT) infrastructure and economic growth: A causality evinced by cross-country panel data. *IIMB Management Review*, *30*(1), pp. 91-103.

Pradhan, R.P., Sarangi, A.K., Maity, C. and Behera, R.R., 2022. ICT infrastructure and economic growth in G-20 countries: New insights form ARDL modelling. *The Journal of Developing Areas*, *56*(1), pp. 47-58.

Romer, P.M., 1990. Endogenous technological change. *Journal of political Economy*, *98*(5, Part 2), pp. S71-S102.

Schumpeter, J. and Backhaus, U., 1934. The theory of economic development. In *Joseph Alois Schumpeter: Entrepreneurship, Style and Vision* (pp. 61-116). Boston, MA: Springer US.

Solow, R.M., 1956. A contribution to the theory of economic growth. *The quarterly journal of economics*, *70*(1), pp. 65-94.

Tripathi, M. and Inani, S.K., 2020. Does information and communications technology affect economic growth? Empirical evidence from SAARC countries. *Information Technology for Development*, *26*(4), pp. 773-787.

Usman, A., Ozturk, I., Hassan, A., Zafar, S.M. and Ullah, S., 2021. The effect of ICT on energy consumption and economic growth in South Asian economies: an empirical analysis. *Telematics and Informatics*, *58*, p. 101537.

Vu, K.M. and Asongu, S., 2020. Backwardness advantage and economic growth in the information age: A cross-country empirical study. *Technological Forecasting and Social Change*, *159*, p. 120197.

World Development Indicator (WDI); The World Bank: Washington, DC, USA, 2021.