Pakistan Economic and Social Review
Volume 59, No. 2 (Winter 2021), pp. 287-310

INFORMATION AND COMMUNICATIONS TECHNOLOGIES, HUMAN DEVELOPMENT AND ECONOMIC GROWTH: THE CASE OF PAKISTAN

JAHANZEB KHAN, AZIZ AHMAD KHAN AND RANA MUHAMMAD ADEEL–FAROOQ*

Abstract. Information communication technologies (ICTs) play a vital role in enhancing the economic growth of countries. Therefore, in this context, this study measures the consequences of ICTs, human development, trade and gross fixed capital formation on Pakistan's economic growth over the period of 1990-2018. For the estimation, ARDL estimation method is employed. The outcomes indicate that ICTs, human development and gross fixed capital formation significantly accelerate the pace of economic growth of Pakistan. This study based on the empirical findings suggests policy makers of Pakistan to invest further in ICTs sector to accumulate higher economic growth in the long run. Furthermore, Pakistan should invest to upgrade the skills and knowledge of its workforce too for sustained economic growth.

Keywords: ICT, Human development, Economic growth, ARDL, Pakistan

JEL Classification: O32, O15, O4, C13

*The authors are respectively PhD Scholar at Department of Public Administration, University of Sindh, Jamshoro, Lecturer at Department of Economics, Government SE College Bahawalpur and Assistant Professor at Department of Economics University of Sahiwal, Sahiwal – Pakistan.
Corresponding author's e-mail: adeel@uosahiwal.edu.pk

I. INTRODUCTION

Dynamically evolving Information and communication technologies (ICTs) are known as the medium of change and have asserted various positive effects on the economic development across the globe. In recent times, all the firms and governments employ internet connection, telephones and computers to facilitate the operation and therefore, investing immensely in the development and diffusion of ICTs (Ali et.al, 2020a; Debono, 2002; Yusuf, 2011). The ICTs are also known as two side of the same coin in order to achieve sustainable development with regard to economic growth compounded with long-run sustainability and controlling environmental problems (Hou et al., 2015). Consequently, investment in ICT has an imperative role in the up-gradation of production techniques and, through this; the added value is also increased. Besides, increase growth, development of productivity and welfare in both developed and developing countries is contributed by ICTs (Biggeri and Mauro, 2018). It facilitates in organizing, gathering, publication and storing data (Khan, Adeel-Farooq, Akram, & abbasi, 2021; Khan, Burdey, & Adeel-Farooq, 2020; Niebel, 2014). There is empirically little evidence to support the assertion that ICTs play a role to spur the economic growth (Jorgenson and Vu, 2013; Jorgenson and Samuels, 2011; Inklaar et al., 2008; Jorgenson et al., 2005; Jorgenson, 2001).

Likewise, for a developing economy, human capital development is also the relevant factor to achieve sustainable economic development (Adeel-Farooq, Bakar, & Raji, 2017; Adeel-Farooq, Bakar, & Raji, 2020; Jones, 1996; Barro, 2001). The presumption will be rational: enhancing the level of human capital, especially through providing educational opportunities by ICT, is a vital factor to achieve rapid and sustainable economic growth (Oluwatobi and Ogunrinola, 2011; Jaiyeola, 2015). The impact of ICTs and human capital development in determining the economic growth has long been debated from empirical stand point and theoretical basis. Lucas (1990), for instance, revealed the new growth theory suggests that economic growth is significantly determined by the human capital. On the other end, Romer (1990) came up with the assertion that research and development and spillover from its processes determine the economic growth. Lucas (1988) and Romer (1986) suggested that in endogenous growth model, the vital source of

enhancing divergence and returns in growth rate between undeveloped and developed economies are human capital. Theoretically, there seems to be a straightforward relationship while empirical studies have established a mixed outcome due to variables employed in place of human capital development in determining the economic development. Mankiw, Romer, and Weil (1992) and Barro (1991), for instance, revealed a significant and positive relationship between growth and human capita, whereas Dulleck and Foster (2008) revealed the relationship between equipment investment, a variable used against the human capital, and economic growth is negative.

Despite, in emerging countries, there is widespread dissemination of ICT, the association between economic development and ICTs in these economies still remains questionable throughout the world. In this context, Pakistan is not an exception. The present state of ICTs in Pakistan represents enhanced growth of total information technology return, valued of 3.1 billion dollars (US). Using the public scale spectrum and development policies for the future generations, mobile services and broadband penetration have risen to 40.7 million, up from 3.7 million. In Barcelona, Spain, the "Government Leadership Award 2017" was won by the Ministry of Information Technology and Telecommunication. In response to the ICTs' rapid transformed character in every sector of the economy, the Digital Pakistan Policy 2016-17 was formulated by the Pakistan in order to rapidly transform the IT. During 2017, US$ 55 million was the foreign direct investment's inflow to ICTs and during the previous year, telecom operators invested US$ 287.6 million, cellular mobile sector was the main reason behind such a massive investment. Furthermore, during 2016-17 the sector invested US$ 262 million. Likewise, during 2016-17 broadband subscribers grew significantly and risen from 32.29 million to 42.36 million, indicating 31% growth in March, 2018. Government of Pakistan, by acknowledging the significance of ICTs, has given a constructive environment for the IT industry. In this context, Government has given several incentives to the industry including: IT exports were exempted till June, 2019, the 100% equity ownership were offered to foreign investors, repatriation of dividends and capital was allowed upto 100%, and 7 years' tax holidays were given to the venture capital funds (Government of Pakistan, 2019).

In the context of the above discussed situation, Perhaps, Pakistan is an appropriate case study to explore the association between ICTs, human capital and economic development. There are few researches found, using quantitative analysis, and applying advanced econometric approach to their studies. It is of paramount significance to apply advanced econometric approach such as ARDL to quantify and explore the role of ICTs and human development to enhance Pakistan's economic growth. This study is an attempt to fill this gap.

II. LITERATURE REVIEW

There are several studies conducted in different countries of the world that have explored the relationship between ICTs and economic development. The direct relationship between economic development and ICTs is also supported by the theories of economics. In theories of economics, the ICTs is used as external factor which stems from the communal or government choices, the multiplier effects and the modernization (Colecchia and Paul, 2002; Dutta, 2001; Qidwai, 2011; Shahiduzzaman and Alam, 2014; Pradhan et al., 2014; Ishida, 2015).

Different studies have highlighted that the association between economic development and ICTs is positive (Saunders et al., 1983; Yoo and Kwak, 2004; Hwang and Shin, 2017a; Lee et al. 2017; Asongu and Nwachukwu, 2018). The classical work done by Cronin et al. (1991) showed that, in the US, the relationship between ICTs and economic development is causal and a bi-directional, the place that considerably attracts economists' interest. The causal association between economic development and ICTs is backed by most studies (Nisar et al., 2011; Pradhan et al., 2013; Bell, 2015), on the other end, there are few studies indicated no causality relationship between economic development and ICTs (Shiu and Lam, 2008; Veeramacheneni et al., 2008). The earlier studies critical appraisal reveals that across all countries association between these two variables is not identical one.

No consensus is found, at present, on the nature of association between economic growth and ICTs. There are four possible associations on the causal link among economic development and ICTs, presented in empirical literature, the feedback hypotheses, no causality hypothesis, One-way ICT-led development hypothesis, and one-way growth-led

hypothesis. Several studies, in this context, have demonstrated evidence, supporting the ICT-led development hypothesis (Mehmood and Siddiqui, 2013; Ahmad and Krishnasamy, 2012; Shiu and Lam, 2008; Cieslik and Kaniewsk, 2004; Chakraborty and Nandi, 2003; Dutta, 2001). Several studies also supported the growth-led ICT hypothesis (Pradhan et al., 2013; Veeramacheneni et al., 2008; Beil et al., 2005). Moreover, most studies have showed the support for a two-way causal relationship (Pradhan et al., 2013; Lam and Shiu, 2010; Ramlan and Ahmad, 2009; Chakarborty and Nandi, 2009; Shiu and Lam, 2008; Yoo and Kwak, 2004; Cronin et al., 1993). There are fewer studies highlighting the support for no causal relationship (Shiu and Lam, 2008; Veeramacheneni et al., 2008). In recently conducted comparative studies also highlighted a positive relationship between economic development and ICTs. Likewise, Niebel (2018) indicated the relationship between economic development and ICTs in advance and emerging countries. Sepehroust (2018) provided analysis of economic and development and ICTs for the OPEC countries. Moreover, Stanley et al. (2018) provided meta-analysis for the economic growth and ICT association for developing and developed countries. Majeed and Ayub (2018) presented a comparative global analysis of economic development and ICTs nexus, indicating a positive relationship. Likewise, Adonsou (2019) highlighted, in this context, identical findings for Sub-Saharan African economies.

The critical appraisal of the literature highlighted that in advance countries, the role of ICTs in rapidly increasing economic development has been extensively studied (Adonsou, 2019; Sepehrdoust, 2018; Majeed and Ayub, 2018; Niebel, 2018). In case of Pakistan, there is dearth of studies explaining the relationship between ICT and economic growth. In a recent study, Rahman et al., (2021) have empirically argued that ICT imports affect the economic growth of pakistan. Nevertheless, no relationship has been overved between ICT and economic growth in case of Pakistan. Recognizing the dearth of studies regarding ICT and economic growth in Pakistan, it is of paramount significance to conduct study in this body of knowledge by applying ARDL econometric approach. This gap in the body knowledge is filled with the present study. This study significantly contributes in the literature of economics.

In the same way, extensive studies have been conducted on human capital development, and economic development (Jaiveola, 2015; Oluwatobi and Ogunrinola, 2011; OECD, 2005; Barro, 2001; Jones, 1996). In so doing, It's significant to mention, the human capital development is a vital component to attain the inclusive development and growth (Joshi, Hughes, and Sisk, 2015; Asadullah, Savoia, and Mahmud, 2014; Sen, 2013).

Evidence from extant literature supported the fact that there is a vital role of ICTs in enabling the development of human capital (Cheng, Mitomo, Otsuka, and Jeon, 2015; Martin, Ciovica, and Cristescu, 2013; Ilmakunnas and Miyakoshi, 2013). The ICTs' potential in facilitating the development of human capital is demonstrated in how autonomous higher institutions, organizations, and alliances invest in the programs of distance and online learning, open-online course, and educational mobile device and smart board as infrastructure (Armey and Hosman, 2015; Sanda, Binuyo, and Oduyoye, 2013; Obiri-Yeboah, Fosu, and Kvere-Djan, 2013)

Theoretical Literature

Over the previous few decades, ICT has emerged as an important factor of economic growth other than human and physical capital (Saidi & Mongi, 2018). Likewise, several growth theories such as endogenous, neoclassical and classical explained the determinants of economic growth. For instance, Romer (1986) started both the empirical and theoretical analysis emphasizing on growth process' endogeneity as compared to neoclassical, Solow-type, growth models (Solow, 1956) in which the endogenous technical changes and the aggregate function approach is used (Roller and Waverman, 2001). After this, several studies have tried to disaggregate a national economy's elements which determine the economic growth (Aghion and Howitt, 1998). Though, factors of economic growth could be categorized into three different kinds. First category emphasized on the accumulated broad capita l including several kinds of physical capitals and human capital. The second category considers external economies or spillovers. The third category considers that the engine of economic growth is industrial innovation (Grossmanm and Helpman, 1994).

Began in 1990s, plenty of studies have scrutinized the relationship between ICTs and economic growth. The studies found that the economic growth is enhanced with the a useful instrument, the ICTs. Draca et al., (2007) found that ICTs' impact on economic growth has been usually studied under the umbrella of total factor productivity, a measure of labor inputs and rising output holding constant capital. Biagi (2013), for example, claimed that the growth accounting process normally quantifies such contributions of technology through Solow residual which, in its essence, is unaccounted growth after taking into account input. The rise in Solow residual can be contributed by ICTs in different ways including; (i) improved marginal productivity and organizational efficiency of skilled labor (for instance, enterprise software), (ii) highly efficient dissemination of information (for instance, texting and cell phones), and (iii) more efficient market transaction and reduced transaction costs (for example, online banking).

Solow (1956) used the technology in the growth model for the first time; Mankiw, Romer and Weil (1992), Barro and Sala-i-Martin (1991, 1992), and Barro (1991) propelled technology in the growth model. It was found in these studies that technological progress significantly contributes in economic growth. In contrast to the Solow model, in which technology is placed as exogenous variable, technological progress is considered as endogenous in a new growth model. Grossman and Helpman (1991), Aghion and Howitt (1992), Aschauer (1989), Romer (1990, 1993), and Lucas (1988) have used technological progress as endogenous. For instance, Lucas (1988) highlighted technological progress as dependent on human capital. Romer's (1988) model went above by emphasizing that it depends on search for innovative ideas too. For him, technological progress is affected by the search for innovative ideas which, in turn, leads to economic growth.

For this reason, theoretical framework for this study is based on human capital theory model produced by Romer (1990). It is asserted by the theory that not only capital and labor influences growth but human capital as well, as shown.

$$Y_t = f\left(K_t, L_t, H_t\right) \qquad (1)$$

where Y_t is output, K_t is capital, L_t is labour and H_t is human capital. Introducing ICT explicitly into the model in equation 1 above, we have the following:

$$Y_t = f\left(K_t, L_t, H_t, T\right) \qquad (2)$$

III. DATA DESCRIPTION AND ESTIMATION STRATEGY

DATA DESCRIPTION

The present study aims to explore the association between economic growth and ICTs in Pakistan's context over the 1990-2018 period. In addition, three variables essential for economic growth namely gross fixed capital formation (GFCF), human development index (HDI) and trade openness are used as controlled. The data for the explained and explanatory variables is obtained from the World Development Indicators (WDI). It is worthy to note that the data availability on ICTs (Mobile cellular subscriptions (per 100 people)) has restricted this study to conduct analysis over the selected period. Table 1 contains the variable names, measurements of the variables and symbols used.

TABLE 1

Variables Description

Variable Name	Measurement	Symbol used
ICTs	Mobile cellular subscriptions (per 100 people)	ICTs
GDP Per Capita	GDP Per Capita (constant 2010 US$)	GDP
Gross Fixed capital formation	Gross Fixed Capital Formation (% of GDP)	GFCF
HDI	Human Development Index Score	HDI
Trade Openness	Trade (%GDP)	Trade

METHODOLOGY

Model Specification

In order to measure the influence of ICTs, HDI, GFCF, Trade on economic growth of Pakistan, the present study employ the endogenous growth theory as an underpinning theory. This growth theory considers two factors essential to spur the pace of economic growth: research and development (R&D) and human capital. (Aghion, & Howitt 1998; Turnvosky, 2001; Hye, & Lau, 2015). It is further asserted that particularly in the context of developing countries, maximum growth related benefits can be reaped if sufficient human capital is available there (Abramovitz 1986). As, this study focuses on Pakistan, a developing country, for this reason, endogenous growth theory is used as a theoretical framework for this examination in order to analyze the consequences of ICTs on Pakistan's economic growth. To achieve this purpose, the following econometric model has been employed in the study:

$$\ln GDP = \alpha_0 + \alpha_1 \ln ICT_s + \alpha_2 \ln HDI + \alpha_3 \ln GFCF + \alpha_4 \ln TRADE + \varepsilon_t \qquad (1)$$

where *ln* indicates the natural log, and all the explanatory and explained variables have been transformed into natural log. Taking natural log makes it flexible to interpret the outcomes as elasticities.

Estimation Strategy

This study uses time series data for analysis and the estimation procedure of the current study comprises of unit root tests, co-integration analysis, short run and long run analysis.

Unit root tests

Time series analysis begins by examining the integration order of the variables. Hence; this study examine stationarity of the regressand and regressors through two extensively employed and efficient unit root tests namely Augmented Dickey Fuller (ADF) and Philips Peron (PP) tests (Dickey and Fuller, 1979; PP). The mathematical equation of the ADF test is given below:

$$\Delta V_t = \delta + \vartheta_{yt-1} + \delta T + \sum_{j=1}^{k} \theta_j \Delta V_{t-j-1} + \mu_t \qquad (2)$$

In equation (2), V is a series at time t; δ indicates a constant term, *k* is used for the number of lags and μ_t shows the error term. The null hypothesis of series having unit root test may not be rejected if the estimated ADF test value comes less than the critical value. In other words, it shows the presence of unit root problem. Nevertheless, if the ADF test statstics is higher than the critical value; the null hypothesis may be rejected and the series is considered to free of unit root problem. Likewise, PP test also employs the similar equation; however, it's based on the non-parametric correction for serial correlation's identification (Belaid and Abderrahmani, 2013).

ARDL Approach

Auto Regressive Distributed Lag (ARDL) approach is applied in order to examine long run co-integration among the variables and for short and long run analysis as well. This estimation technique possesses several striking properties in contrast to other co-integration technique such as Engle & Granger (1987), Johansen & Juselius (1990) co-integration methods and therefore, it has been extensively employed in the recent time series analysis literature. ARDL estimation method may be applied even when the series are integrated at level I(0), or at first difference I(1) or having the combination of I(0) and I(1). Likewise; another interesting feature of this dynamic method is that it is appropriate for examining the co-integration in the short samples too (Pesaran et al. 2001; Pesaran & Shin, 1999). Additionally, while estimating the long and short run parameters, ARDL estimation method fixes the endogeneity issue and yields reliable t-statistics (Narayan, 2005). Similarly, an error correction model (ECM) through a flexible linear transformation can be derived from the ARDL technique, which simply combines short run adjustments with the long run equilibrium and does not lose the long run information (Pesaran and Shin, 1999).

ARDL method involves two steps: first, it measures the long run co-integration among the variables and second, short run and the run models are estimated (Boutabba, 2014). The following unrestricted error correction model explained the co-integration equation employed by the ARDL estimation method:

$$\Delta \ln GDP_t = \alpha_0 + \alpha_1 \sum_{i=0}^{k} \Delta \ln DGP_{t-1} + \alpha_1 \sum_{i=0}^{k} \Delta \ln ICTs_{t-1} + \alpha_2 \sum_{i=o}^{k} \Delta \ln HDI_{t-1} + \alpha_3 \sum_{i=o}^{k} \Delta \ln GFCF_{t-1} \quad (3)$$
$$+ \alpha_4 \sum_{i=1}^{k} \Delta \ln Trade_{t-1} + \beta_1 \ln GDP_{t-1} + \beta_2 \ln ICTs_{t-1} + \beta_3 \ln HDI_{t-1} + \beta_4 \ln Trade_{t-1} + \mu_t$$

In equation (3), 'Δ' shows the first difference operator, μ_t is used for the residuals of the model. The terms having the summation symbols indicate the error correction dynamics. Whereas, the second section of the equation shows the long run association. This equation involves the time trend variable to grasp the independent changes related to time.

Through ARDL technique, $(p+1)^k$ numbers of regressions are estimated in order to acquire the optimal lag length for variables, where p indicates the optimal lag length and k shows the variables. This lag length selection is based on two criteria namely Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). Additionally, the bound testing process with the null hypothesis of no integration is based on the combined F-statistics. Two sets of critical value have been mentioned by Pesaran et al. (2001) and Narayan (2005). One critical value set consider that all the variables in ARDL models are I(0) while the second critical set of value is computed over the supposition that variables are I(1). The null hypothesis of no co-integration may be rejected if the estimated F-statistics comes higher than the upper critical bound. Nevertheless, decision about co-integration becomes inconclusive if the F-statistics lies between the two bounds. In this scenario, Banerjee et al. (1998) are of the view that co-integration will be established with the help of ECM term. Additionally, the stability of the long and short run models are observed through the cumulative sum (CUSUM) and cumulative sum of squares (CUSUM-Square) (Pesaran and Pesaran, 1997; Brown et al. 1975).

IV. EMPIRICAL OUTCOMES AND DISCUSSION

EMPIRICAL OUTCOMES

Descriptive Statistics

The study commences empirical analysis by exhibiting the descriptive statistics of the data. Table 2, contains the descriptive statistics of the data.

TABLE 2

Descriptive Statistics of Data

Variable	GDP	ICT	GFCF	HDI	Trade
Mean	917.78	26.41	17.35	0.483	32.29
Median	899.94	3.20	17.59	0.486	32.86
Maximum	1197.91	72.55	20.70	0.56	38.49
Minimum	736.11	0.01	14.12	0.40	25.30
Std. Dev.	130.11	30.33	1.75	0.05	3.95
Observations	29	29	29	29	29

Unit Root Tests' Outcomes

In this research, stationarity of the data is examined by employing two efficient unit root tests such as ADF and PP. The outcome of the two tests for each variable is shown in Table 3. It is obvious from the outcomes in Table 1 that some of the variables are integrated at level and fist difference. In this case, ARDL estimation technique is justified to be employed for the analysis.

TABLE 3

Results of ADF and Philips Peron Tests

	Augmented Dicky Fuller (ADF)				Philips Peron (PP)			
	I(*0*)		I(*1*)		l I(*0*)		I(*1*)	
Variable	t-test	Prob	t-test	Prob	t-test	Prob	t-test	Prob
GDP	-4.49	0.00*	-4.23	0.00*	-3.41	0.00*	-4.21	0.00*
ICT	-0.05	0.99	-3.74	0.03**	-0.33	0.23	-3.82	0.03**
HDI	-1.74	0.70	-3.34	0.02**	-1.15	0.91	-3.3	0.02**
GFGC	-2.12	0.51	-4.94	0.00*	-4.94	0.00*	-6.74	0.00*
Trade	-2.25	0.44	-5.09	0.00*	-2.25	0.44	-5.09	0.00*

Note: *,**Significant at 1 and 5 percent level, respectively

Bounds Test of Co-Integration Outcomes

After checking the stationarity of explained and explanatory variables, co-integration in the long run among variable has been

examined by using the Bound test approach. The estimated F-Statistics along with the critical values is shown in Table 4. Boutabba, (2014) has mentioned that F-statistics follows a no-standard distribution and depends on the four key factors. These factors include: variable orders in the model; number of independent variables; inclusion of the trend/intercept in model and the sample size. The F-statistics (F=15.88) in Table 4 is sufficiently higher than the critical values of lower and upper bounds. In other words, the null hypothesis of no co-integration may be rejected and it proves that the co-integration among the variables exists.

TABLE 4

Bound Test of Co-integration

Bound Critical Value				
	99%		95%	
F-statics	1(0)	I(1)	1(0).	I(1)
15.88	3.29	4.37	2.56	3.49

Long and Short Run Outcomes

The short and long run empirical outcomes obtained through ARDL estimation method are exhibited in Table 5 and Table 6 respectively. The findings in Table 5 indicates that all explanatory variable are statistically significant except trade and are having a robust short-run association with the economic growth of Pakistan. For instance, it is demonstrated in Table 5 that 1% increase in ICTs positively affects the economic growth of Pakistan by 0.1% in the short run. Likewise, HDI is also found to have a positive relationship with the economic growth of Pakistan. Table 5 shows that 1% increase human development index enhances economic growth of Pakistan by 1.71%. In the short run, coefficient of HDI has been discovered to accelerate the economic growth more than any other explanatory variable. In the same way, 1% increase in GFCF significantly is found to accumulate short run economic growth by 0.14% in Pakistan. Nevertheless, trade in short run is revealed to have an insignificant link with economic growth of Pakistan. Additionally, the EC term is significant, having a negative sign and less than unity. The coefficient value of ECT (-0.61) suggest that deviations from the equilibrium level of economic growth in the long run in a year are

adjusted by 64% over the next year. Moreover, the value of R2 (0.75) indicates that the explanatory variables explain 75% variations in the dependent variable.

TABLE 5

Short-run Outcomes

Variable	Coefficient	t-ratio	Prob.
LICT	0.01	2.03	0.04**
LHDI	1.71	6.80	0.00*
LGFCF	0.14	4.42	0.00*
LTrade	0.02	1.05	0.30
ECM(-1)	-0.61	-10.86	0.00*
R^2	0.75		
Adjusted R^2	0.74		
D.W Statistics	2.29		

Note: Note: *,**Significant at 1 and 5 percent level, respectively

Table 6 contains the long run outcomes and it is evident here that all the explanatory variables, except trade are having positive and significant relationship with the economic growth in the long run too. The coefficient of ICTs in Table 6 demonstrates that 1% increase in ICTs positively influences the economic growth of Pakistan by 0.04% in the long run. Similarly, HDI's coefficient value is significant and indicating that 1% increase in HDI accelerate the economic growth in long run by 2.78%. Likewise, GFCF is also discovered to have a positive and significant association with economic growth and coefficient of GFCF in Table 6 indicates that 1% increase in capital formation increases economic growth by 0.24% in the long run.

TABLE 6

Long-run Outcomes

Variables	Estimates	t-ratio	Prob.
LICTs	0.04	6.41	0.00*
LHDI	2.78	12.11	0.00*
LGFCF	0.24	5.52	0.00*
LTrade	0.03	1.12	0.27

Note: Note: *,**Significant at 1 and 5 percent level, respectively

The study has applied various diagnostic tests, and the outcomes of those tests are given in Table 7 below:

TABLE 7

Diagnostic Tests

Tests	Prob
Bruesh-Godfrey Serial Correlation LM Test	0.34
Ramsey RESET Test	0.38
Bruesh-Pagan-Godfrey	0.14

In order to detect the serial correlation, Lagrange Multiplier test of Breusch-Godgrey is used. The p-value (0.34) shows there is no issue of serial correlation in the data. In the same way, to ensure functional form, Ramsey RESET test is employed. Results (0.38) revealed that the model is appropriately specified. Additionally, heteroscedasticity is checked through Bruesh-Pagan-Godfrey test. The test statistics (0.14) reveal that issue of heteroscedasticity does not exists in the data.

Stability of the Parameters

To stability of parameters is examined with the help of CUSUM and CUSUMSQ as show in Figure 1 and Figure 2 respectively. The CUSUM and CUSUMSQ statistics plots are within the critical limits which indicate that all the coefficients of the ECM are stable. Therefore, the study's may be employed for the policy purpose.

The plots of CUSUMSQ and CUSUM, recursive coefficients' graphs, and leverage plots presented in figure 1,2,3, and 4 respectively, put forward that all coefficients in the estimated Autoregressive Distributed Lag (ARDL) model are stable.

FIGURE 1

Plot of CUSUM

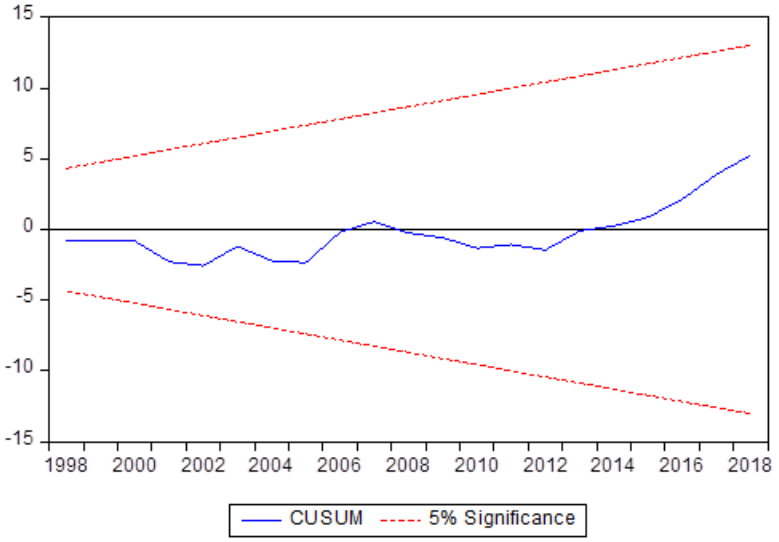
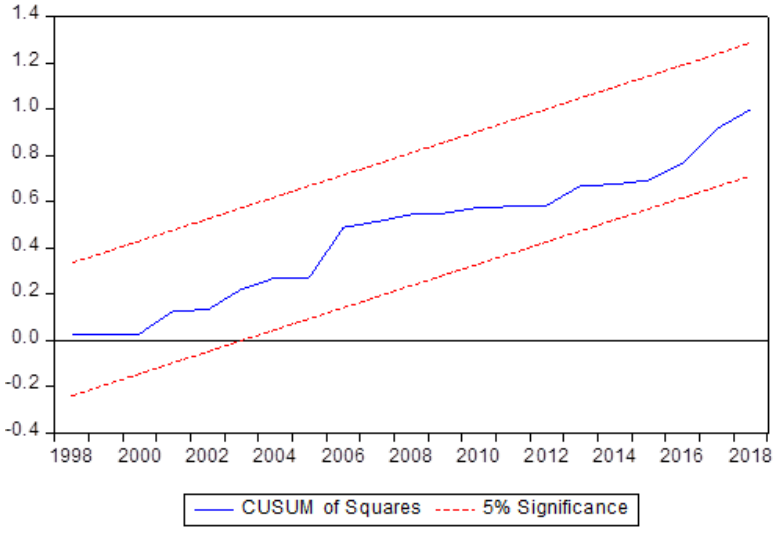


FIGURE 2

Plot of CUSUMSQ



DISCUSSION SECTION

The influence of ICTs along with some other vital explanatory variables such as HDI, GFCF, and Trade on economic growth of Pakistan has been examined in the current study. The empirical findings of the study indicate that ICTs have substantially enhanced the economic growth of Pakistan in the short and as well as long run. The possible reason for this positive relationship between ICTs and economic growth of Pakistan could be that in recent times, substantial development in the use of ICTs particularly in the banking, health and education sectors, and government offices has been done. This has adequately eased and accelerated the business activities, search for employment opportunities which in return has augmented the economic growth of Pakistan. Likewise, results of the current study show that HDI has also enhanced the economic growth of Pakistan. Since, 1990, as a result of significant investments and efficient policies by the governments of Pakistan in education and health sectors, HDI score of the country has increased. Consequently, this increase in HDI scores over the previous few decades has positively influenced the economic growth of Pakistan. In the same way, outcomes of the study indicate that GFCF is another vital contributing factor to economic growth of Pakistan. The plausible reason for this positive growth effect of GFCF could be that since 1990, net addition to the fixed capital of the country has hugely increased and this has facilitated the economy to attain stability and growth. Therefore, GFCF has proved to be beneficial for the economic growth of Pakistan.

V. CONCLUSION AND POLICY SUGGESTIONS

The debate on twin deficits hypothesis proposed by the Keynesian income expenditure approach is well known and it has undergone several empirical investigations. Because of four separate sets of findings, the existing relevant literature is now inconclusive. The first set of literature seconds the twin deficit hypothesis and suggests a significant impact of budget deficit on current account deficit. The second body of research suggests that both the deficits have a bidirectional link. Another line of research suggests that the two macroeconomic variables have a reverse causal relationship. The final set of studies backs up the Ricardian neutrality hypothesis by demonstrating that the two deficits are unrelated.

This study measures the relationship between ICTs and economic growth in the context of Pakistan. For estimation, dynamic ARDL bound testing mechanism has been employed. The outcomes of the study show that ICTs enhance the economic growth of Pakistan. In addition, the findings divulge that human development and gross fixed capital formation augment the economic growth too. Nevertheless, the association between trade and economic growth is discovered to be insignificant.

This study based on the empirical outcomes suggests that Pakistan should further invest in the ICTs. This way, it will on one hand smooth the economic activities within the country. On the other hand, it will assist to attract substantial foreign direct investment which will also prove to be beneficial for the health of the economy. Likewise, this study suggests that Pakistan should dedicate substantial resources for the development of human capital as it has also been proven to accelerate the economic growth of the country. In the same way, investment for the capital formation will be useful in creating employment opportunities and enhancing the pace of economic growth. In addition, future research may be conducted to explain the association between ICT and economic growth in Pakistan by employing other proxies for ICT and by employing latest advanced econometric techniques.

REFERENCES

Adeel-Farooq, R. M., Bakar, N. A. A., & Raji, J. O. (2017). Trade openness, financial liberalization and economic growth: The case of Pakistan and India. South Asian Journal of Business Studies.

Adeel-Farooq, R. M., Bakar, N. A. A., & Raji, J. O. (2020). Financial sector development and economic growth: a co-integration analysis for ASEAN countries. International Journal of Economic Policy in Emerging Economies, 13(3), 195-208.

Adonsou, D. F. (2019). Technology, education, and economic growth inSub-Saharan Africa. Telecommunications Policy, 43(2019): 353-360.

Aghion, P.; Howitt, P. 1998. Endogenous growth theory. Cambridge: MIT Press.

Ahmed, E. M., & Krishnasamy, G. (2012). Telecommunications investment and economic growth in ASEAN 5: an assessment from UECM. New Zealand Economic Paper, 46(3): 315-32.

Aker, J. C., & Mbiti, I. M. (2010). Mobile Phones and Economic Development in Africa. The Journal of Economic Perspectives, 24(3), 207-232.

Andrianaivo, M., & Kpodar, K. (2011). ICT, financial inclusion, and growth: Evidence from African countries (Working Paper No. 11/73). International Monetary Fund. IMF Working Paper. Retrieved from: Publications/WP/Issues/ 2018/10/21/ICT-Financial Inclusion and Growth Evidence from African Countries-24771.

Banerjee, A., Dolado, J.J., Mestre, R., (1998). Error-correction mechanism tests for cointegration in a single-equation framework. J. Time Ser. Anal. 19 (3), 267–283.

Beil, R. O., Ford, G. S., & Jackson, J. D. (2005). On the relationship between telecommunications investment and economic growth in the United States. International Economic Journal, 19(1): 3-9.

Belaid F, Abderrahmani F (2013) Electricity consumption and economic growth in Algeria: a multivariate causality analysis in the presence of structural change. Energy Policy 55:286–295.

Bell, M. (2015). ICT - Powering Behavior Change in Agricultural Extension. MEAS Brief. October 2015, U C, Davis.

Brown, R.L., Durbin, J., Evans, J.M., (1975). Techniques for testing the constancy of regres- sion relationships over time. J. R. Stat. Soc. 37, 149–163.

Chakraborty, C., & Nandi, B. (2003). Privatization, telecommunications and growth in selected Asian countries: an econometric analysis. Communication Strategies, 52(3): 31-47.

Chakraborty, C., & Nandi, B. (2009). Telecommunication adoption and economic growth in developing countries: do levels of development matter. Journal of Academic and Business Economics, 9(2): 51-61.

Chakraborty, C., and Nandi, B. (2011). Mainline telecommunications infrastructure, levels of development and economic growth: evidence from a panel of developing countries. Telecommunication Policy, 35(1): 441-449.

Choi, C. (2015). The Effect of the Internet on Economic Growth: Evidence from Cross-Country Panel data. *Economics Letters*, *105*(1): 39-41.

Choi, C., & Yi, M. H. (2009). The Effect of the Internet on Economic Growth: Evidence
from Cross-Country Panel data. Economics Letters, 105(1): 67-75.

Cieslik. A., & Kaniewsk, M. (2004). Telecommunication, infrastructure and regional economic development: the case of Poland. Regional Studies, 38(6): 713-25.

Colecchia, A., & Paul, S. (2002). ICT investment and economic growth in the 1990s: is the United States a unique case? A comparative study of nine OECD countries. Revolution of Economic Dynamics, 5(2): 408-442.

Cronin, F. J., Colleran, E. K., Herbert, P. L., & Lewitzky, S. (1993). Telecommunications and growth: the contribution of telecommunications infrastructure investment to aggregate and sectoral productivity. Telecommunication Policy, 17(9): 677-690.

Cronin, F. J., Parker, E. B., Colleran, E. K., and Gold, M. A. (1991).Telecommunication infrastructure and economic growth: an analysis of causality. Telecommunication Policy, 15(6): 529-535.

Debono, B. (2002). Assessing the social impact of public libraries: what the literature is saying. Aplis, 15(2): 80-95.

Dutta, A. (2001). Telecommunications and economic activity: an analysis of granger causality. Journal of Management and Information System, 17(4): 71-95.

Government of Pakistan, (2019). Economic Survey of Pakistan Finance Division Economic Advisor's Wing, Islamabad.

Inklaar, R., Timmer, M. P., & van Ark, B. (2008). Market services productivity across Europe and the US. Economic Policy, 25(33): 139-194.

Ishida, H. (2015). The effect of ICT development on economic growth and energy consumption in Japan. Telecommunication and Information, 32(1): 79-88.

Jorgenson, D. W. (2001). Information technology and the US economy. American Economic Review, 91(1): 1-32.

Jorgenson, D. W., & Samuels, J. D. (2011). Information technology and U.S. productivity growth: Evidence from a proto type industry production account. Journal of Productivity Analysis, 36(2): 159-175.

Jorgenson, D. W., & Vu, K. (2013). The emergence of the new economic order: growth in the G7 and the G20. Journal of Policy Modeling, 35(3); 389–399.

Jorgenson, D. W., & Vu, K. M. (2005). Information technology and the World economy. The Journal of Scandinavian Journal of Economics, 107(4): 631-650.

Jorgenson, D. W., Ho, M. S., & Stiroh, K. J. (2005). Information technology and the American growth resurgence. Cambridge, M A: The MIT Press.

Khan, J., Burdey, M. B., & Adeel Farooq, R. M. (2019). Governance and Economic Growth: A Case of Selected SAARC Countries. Pakistan Journal of Social Sciences (PJSS), 39(4).

Khan, J., Farooq, R. M. A., Akram, K., & Abbasi, M. S. (2021). Is Corruption Detrimental for Economic Growth? A Panel Data Analysis of Selected South Asian Economies. South Asian Studies, 1(35).

Lam, P. L., & Shiu, A. (2010). Economic growth, telecommunication development and productivity growth of the telecommunication sector: evidence around the world. Telecommunication Policy, 34(4): 185-199. Liang, Q., & Teng, J. Z. (2006). Financial Development and Economic Growth: Evidence for China. The Journal of China Economic Review, 17(4): 395-411.

Majeed, M. T., & Ayub, T. (2018 .Information and Communication Technology (ICT) and Economic Growth Nexus: A Comparative Global Analysis. Pakistan Journal of Commerce and Social Sciences. 12(2): 443-476.

Mehmood, B., & Siddiqui, W. (2013). What causes what? panel co-integration approach on investment in telecommunications and economic growth: case of Asian countries. Romanian Economic Journal, 16(47):3-16.

Narayan, P.K., (2005). The saving and investment nexus for China: evidence from cointegration tests. Appl. Econ. 37, 1979–1990.

Niebel, T. (2014). ICT and Economic Growth: comparing Developing, Emerging, and Developed Countries (ZEW Discussion Papers 14-117). ZEW-Zentrun for Europaische Wirtschaftsforschung/ Center for European Economic Research (ZEW Discussion Papers 14-117).

Niebel, T. (2018). ICT and Economic Growth–Comparing Developing, Emerging and Developed Countries. World Development, 10(4): 197-211.

Nisar, M. W., Munir, E. U., & Shad, S. A. (2011). Usage and Impact of ICT in Education Sector; A Study of Pakistan. Australian Journal of Basic and Applied Sciences, 5(12): 578-583.

Pesaran, H.M., Shin, Y., 1999. Autoregressive distributed lag modelling approach to cointegration analysis. In: Storm, S. (Ed.), Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium. Cambridge University Press, Cambridge.

Pesaran, M. H., Shin, Y. & Smith. R. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. Journal of Applied Economics, 16(3): 289-326.

Pesaran, M.,& Pesaran, B., (1997). Working with Microfit 4.0: Interactive Economic Analysis. Oxford University Press, Oxford.

Pesaran, M.H., Shin, & Y., Smith, R.J., (2001). Bounds testing approaches to the analysis oflevel relationships. J. Appl. Econ. 16, 289–326.

Pradhan, R. P., Arvin, M. B., Norman, N. R., & Bele, S. K. (2014). Economic growth and the development of telecommunications infrastructure in the G-20 countries: a panel-VAR approach. Telecommunication Policy, 38(7): 634-649.

Pradhan, R. P., Bele, S., & Pandey, S. (2013). Internet-growth nexus: evidence from cross country panel data. Applied Economic Letters, 20(16): 1511-1525.

Pradhan, R. P., Bele, S., & Pandey, S. (2013). The link between telecommunication infrastructure and economic growth in 34 OECD

countries. International Journal of Technology and Policy Management, 13(3): 278-293.

Qidwai, W. (2011). Advances in information and communication technology (ICT): issues, challenges and opportunities for health care professionals. Journal of the College of Physicians and Surgeons Pakistan, 21(11): 651-653.

Quah, D. (2003). Digital goods and the new economy (CEP Discussion Paper: CEPDP0563). London, UK: Centre for Economic Performance, London School of Economics and Political Science.

Rahman, H. U., Ali, G., Zaman, U., & Pugnetti, C. (2021). Role of ict investment and diffusion in the economic growth: A threshold approach for the empirical evidence from Pakistan. International Journal of Financial Studies, 9(1).

Rahman, H. U., Ghazali, A., & Bhatti, G. A. (2020). Temporal Causality between Human Capital, Trade, FDI, and Economic Growth in Cointegrated Framework. Empirical Evidence from Pakistan. Journal Global Policy and Governance, 9(1), 51-65.

Romer, P.M (1986). Increasing Returns and Long-run Growth. Journal of Political Economy, 94(5), 1002-1037.

Saidi, K., & Mongi, C. (2018). The Effect of Education, R&D and ICT on Economic Growth in High Income Countries. Economics Bulletin. 38(2): 810-825.

Saunders, R. J., Warford, J. J., & Wellenius, B. (1983). Telecommunications and economic development. Washington DC: The John Hopkins University Press.

Sepehrdoust, H. (2018). Impact of information and communication technology and financial development on economic growth of OPEC developing economies. Kasetsart Journal of Social Sciences.

Shahiduzzaman, M., & Alam, K. (2014). The long-run impact of information and communication technology on economic output: the case of Australia. Telecommunication Policy, 38(7): 623-33.

Shiu, A., & Lam, P. L. (2008). Causal relationship between telecommunications and economic growth in China and its regions. Regional Studies, 42(5): 705-718.

Strauss, H., & Samkharadze, B. (2011). ICT capital and productivity growth. EIB Papers,16(2): 8-28.

Thompson, H., & Garbacz, C. (2008). Broadband impacts on state GDP: direct and indirect impacts. Paper presented at the International Telecommunications Society 17th Biennial Conference, Canada.

Turnvosky, S. 2001. Growth in an open economy: some recent developments, in J. Smets, M. Dombrecht (Eds.). How to promote economic growth in the Euro Area.

Veeramacheneni, B., Ekanayake, E. M., & Vogel, R. (2008). Information technology and economic growth: a causal analysis. Southwest Economic Review, 34(1): 75-88.

World Development Indicators (WDI). (2019). World Development Indicators. World Bank, Washington, DC. http://data.worldbank.org/ indicator.

Yoo, S. H., & Kwak, S. J. (2004). Information technology and economic development in Korea: a causality study. International Journal of Technology and Management, 27(1): 57-67.

Yusuf, A. (2011). Libraries and sustainability of democratic order: the place of public library system in Nigeria. Retrieved 12 December 2016 from: http://www.abu.edu.ng/publications.