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Impact of Information and Communication Technology (ICT) Investment on different Components of Human Development in Developing Countries

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Abstract

ICT investment is the key factor of human development in developing countries. Human development has three main components such as GDP, health and education. The current study explores the impact of ICT investment on the components of human development in 67 selected developing countries. Selected developing countries are divided into four panels on the basis of income as lower, lower middle, upper middle and high income countries. Data were collected from World Bank, ITU and Word Information Technology and Services Alliances website for the period of 2000 to 2018. Pesaran, Friedman and Frees CSD tests confirmed the presence of cross-sectional dependency in the variables and consequently, CIPS second generation unit root test were used for stationarity. Kao and Pedroni test and ARDL model were employed to check the long-run cointegration and regression analysis respectively. The regression results showed the mixed findings in different panels. The results explored that ICT investment have different impacts on the components of human development in four panels of the developing countries. Communication investment, software and hardware investment have positive impact on the components of human development in all panels. It is recommended that government should focus on ICT investment to increase GDP, level of education index, life expectancy index and HDI.

Keywords: *ICT Investment, Human Development, Developing Countries, Panel Data.*

Introduction

Information and Communication Technology (ICT) is comprises of software, hardware, networks, collection, storage and transfer of information. It also increases the rate of human capital accumulation as it has access to existing knowledge and information (Goschin & Constantin, 2007). ICT related devices included computer hardware and software, access to internet, radio, television, video and digital cameras etc. ICT has the ability to cover the long distance with relatively low cost (Goschin & Constantin, 2007) by using these equipments in different fields (Ahmed, 2010). ICT is a central part of modern era. People can talk, text and tweet on mobile or entertain themselves by Internet surfing (Van et al., 2011). Apart from individual use, it also affects the people's lifestyle and economy. ICT usage is helpful to increased flow of information and knowledge in the world by reducing the transaction cost and uncertainties in the economic activities (Chen & Dahlman, 2005). ICT eliminates the barriers in the transfer of information and augments factors through coordination and automation. It also increases the efficiency of working, inclusiveness and innovation of new technology in knowledge based economies. ICT is used to improve the level of socio-economic development (Majeed & Ayub, 2018). It improves the efficiency of services and operations at both, organizational and country levels. In industrial economies, ICT serves as an important factor of economic growth. ICT is the main source of technological advancement in the modern economy (Jelassi, 2009) and provides many types of services like, applications regarding education and management systems and new technologies such as cellular phones, using software. The issue of transparency and accountability is also being managed by using ICT (Martínez-Frías, 2003).

Many devices like computer, hardware, software, radio, television, cellular phones, network, & satellite systems come under the umbrella of ICT. Many applications and services are associated with these ICT such as online jobs, online education, video conferencing, online health and transport services. In the last fifty years, ICT impact on economic growth has gradually increased all over the world. Nobel Prize holder Solow said before 25 years ago that, "*People can see the computers everywhere in all sphere of life*". ICT is enhancing impact on economic development and human development. ICT is considered a knowledge base technology; it can be adopted to many applications. ICT play a significant role in production and consumption sectors (van Ark et al., 2011). ICT related devices such as telephone, cell phone, computer and internet are the essential parts of modern life in all over the world. ICT increased access to information and knowledge, connects people, improve the trade of goods and services across the globe. ICT is a key factor for sustainable development (Baliamoune-Lutz, 2003).

Investment in ICT sector is the spending for communication, hardware, software and services in a country (Ahmed, 2006)**.** Investment for software means total spending on different software packages. Hardware investment means spending on equipment related to ICT. Services investment refers to investment on software customization, R&D and IT related miscellaneous. Communication investment means spending on fixed and wireless communication system (Bankole et al., 2011). Since the late 1980s, some world level institutions such as World Bank, United Nation, IMF and ITU have been advocating that increased the investments in ICT sector for developing countries. Investment in ICT and economic development has positive correlation in developing countries. The evidence shows that output of ICT Investment in the developing countries is not same as in the developed world (Ngwenyama et al., 2006). ICT sector is the key driver of economic and human productivity (Strauss & Samkharadze, 2011). ICT investment in the field of software and hardware equipment is main factor of development. It depends on level and classification of economies (Erumban & Das, 2016). ICT investment and human development is different in low income economies as compared to high income economies due to many reasons. Developing economies have many deficiencies such as limited financial resources, unskilled human capital, lack of skills knowledge & computer literacy rate and low knowledge about the benefits of ICT (Niebel, 2018).

ICT is the key factor of human development in the developing economies (Cortés & Navarro, 2011). Human Development Index (HDI) is consists of three components such as living standard, health and education. Living Standard is determined by GDP per capita, knowledge acquisition is determined by literacy rate or education index, health longevity is measured by life expectancy index (Neumayer, 2012). According to International organizations like ITU, WB and IMF, ICT has great potential for socio-economic development in developing economies (Bankole et al., 2011).

In the modern era, ICT is being penetrated into all fields of human development (HD) activities at record rate. In the Information age the distribution of ideas for the human development is power of world economy (Castells, 2000). The use of mobile phone and Internet is helpful to implements international law and protect human rights (Greig et al., 2002).

ICT is the most powerful force in order to achieve the targets of social and economic developments in the developing world. ICT has strong impact on HD. The main purpose of HD is to broaden choices of people that leads to access of knowledge (Ul Haq, 1995). ICT is powerful source of information which is highly beneficial and influential for human development (Lee, 2001). ICT plays an essential role in medicine field for service delivery and knowledge management. ICT has crucial role in the improvement of health outcomes. It can save lives by sharing information regarding health care medicine. ICT is also contributing to enhance the way of learning in the developing world. ICT is also used as a tool in reforming the education systems, access to educational resources, improving the management of education and enhancing academic techniques (Kuyoro et al., 2012).

ICT is used to communicate the people to enhance the standard of living. The knowledge has great value for human development. ICT is a channel used to spread the knowledge among the people. Human development has three essential choices such as acquire knowledge, long and healthy life and enhance the standard of living (Programme, 2003). HDI is an indicator which is used to measure the level of human development of a country (Bankole et al., 2011).The main objective of the current study is to explore the impact of ICT investment on the different components of human development in developing countries.

Theoretical Background

The concept of development is versatile and it mainly focused on standard of living of the people and national income of the country. The concept of development was extended during the late 1980s and social factors were included in development process. According to the David (2002) "National income level is not only address the progress of the country. Economic growth enhance human development, education and health is beneficial for each other (Fielding, 2002). Development is not only measured by GDP, social factors such as education and health is also improving the economic success of a country. The researchers has explore that, there are strong correlation among the economic growth, education, health and political development (Ngwenyama et al., 2006). It is explore in human development report published in 1990that, factors of human wellbeing such as education, health and democracy are important determinant of the development. In 1990, new HDI was introduced. The purpose of the HDI is to estimate the achievement of the country on the basis of three components of human development such as standard of living, knowledge and longevity (Bhanojirao, 1991).

ICT has the productive capacity for the development of nation, it provide access to knowledge, skill, health resources and global market (Y. Chen & Zhu, 2004);(Crafts, 2003). Since the 1980, some institutions like, United Nation (UN), IMF, WB and ITU have been emphasized to increase the investment in ICT sector for developing countries. In 1997 a report was published by United Nation Commission on Science and Technology, according to this report, ICT is the important factor of development of a country. Previous studies shows that, investment in ICTs and economic development has positive correlation in developed nations but in developing countries is not wide (Jalava & Pohjola, 2002) ; (Kenney, 1995) ;(Kenny, 2000). The research regarding ICT investment in developing countries is still limited (Ngwenyama et al., 2006). So there is enormous need for further research in this area.

ICT has main four areas of investment such as communication, software, hardware and internal spending. These areas are possessed different types of knowledge. Hardware is skill knowledge which is used for operating & controlling software. Knowledge regarding software is used for analysis, modeling, and in business processing. Knowledge about the software is more efficient, it facilitate the people to perform their work efficiently and in easy ways (Armour, 2000). Internal spending is very important in ICT field. It is used as bridge between software and hardware knowledge. ICT related investment has positive effect on performance and development of the country (Kim et al., 2008).

Importance of the Study

Many previous studies used the only HDI or one component of HDI such as standard of living as a dependent variable against the ICT investment but in the current study we used three components of HDI and also including HDI as dependent variable which is not seen before (Kim et al., 2008); (Bankole et al., 2011).New methodology are used to explore the relationship between ICT investment and components of HDI such as Friedman's CSD, Pesaran's CSD and Frees's CSD tests are used for checking cross-sectional dependency among variable. CIPS second generation unit root test is used to check the stationarity of the data. Kao test is used for cointegration. New controlled variable are used with ICT related investment variable. Developing countries have less investment in ICT sector as compared with developed world. Therefore, in developing countries, ICT investment decreased over the years. Developing countries have lack of complimentary requirements for ICT, lower absorptive capacity and lack of investment in human capital and R&D (Hashem, 2015).

Review of the Literature

Hashem (2015) estimated the relationship between ICT investment and human development. Different component of ICT investment on different dimensions of human development as well as education and standard of living are observed in the study. Results showed that ICT investment on different sectors have positive effect on human development. By gaining the human development, the economic growth in the country may also boost up. For factors like living standard of people and education and health ICT gives positive result.

Niebel (2018) examined the impact of ICT investment on economic growth in developing, emerging and developed countries. Data from 59 countries with the range of 1995 to 2010 are used for study. Result indicate that ICT having positive impact on economic growth in developing countries. Cortés & Navarro (2011) studied the influence of ICT on human development and economic growth with selected 27 countries of European Union. Study explained the ICT adoption has achieved different levels human development. Study showed that ICT have a substantial impact on human development in selected countries.

Morawczynski & Ngwenyama (2007) investigated the relationship between ICT investment and components of HDI such as education and health index in five western African countries by using Multivariate adaptive regression analysis. It found the significant relation between the ICT investment and HDI. Kim et al., (2008) studied the impact of software, hardware and internal spending investment on economic development in 51 developing countries. The results explore that ICT investment enhance the GDP of the countries.

Bankole et al., (2011) studied effect of ICT related investments on hardware, software, services and telecommunication investment on human development. It is found that the impact of ICT investment on human development is different in low, middle and high income economies. Kozma (2005)studied that ICT investment has positive impact on education and literacy rate. It increase the students' knowledge, skill and attitude. (Aristovnik, 2012) studied the efficiency and impact of ICT on educational outcome in selected European Union and OECD countries. It is found that ICT is very helpful to improve the educational level and quality of learning.

Chetley et al., (2006) studied the use of ICTs investment in health sector in developing countries. Study explore that ICT investment improve the health sectors in different ways. ICT improve the health care delivery units, it helps in sharing of knowledge regarding health issues such as diagnosis of diseases and mapping of public health threat. It makes easy flow of the information between the health works and general public.

Material and Method

Data and Descriptive Analysis

Data of 67selected developing countries for the period of 2000 to 2018 are collected from World Bank (WB), International Telecommunication Union (ITU) and World Information Technology and Services Alliance (WITSA) websites. Selected developing countries were categories into four panels on the basis of income according to WB criteria; such as lower, lower middle, upper middle and high income countries. 14 countries were selected from lower income economies, 20 were selected from lower middle, 23 from upper middle and 10 were selected from high income economies. The name of the countries of above said four panels are mentioned at appendix (list of countries). Table.1 shows the descriptive statistics of four panels. The descriptive statistics shows the difference among the panels. During collection of data, we have faced the issue of missing data. To resolve this issue, we adopted two approaches, by taking the average of previous two values and extrapolate the missing data in Stata.

Table 1: Descriptive analysis

Panels	Mean.	Min.	Max.	Std.Dev.
GDP (Current US$)				
Low income Countries	557.3370	111.9272	1674.003	264.9332
Lower Middle Income Countries	1771.646	258.471	4366.076	1051.955
Upper Middle Income countries	5821.432	622.7421	16054.49	3407.266
High Income Countries	14564.29	3624.198	47741.91	7791.913
Education Index				
Low income Countries	0.340432	0.116000	0.515000	0.100784
Lower Middle Income Countries	0.655626	0.404	0.869	0.120414
Upper Middle Income countries	0.679289	0.481	0.842	0.07888
High Income Countries	0.713117	0.475	0.866	0.07826
Life expectancy index				
Low income Countries	0.576846	0.386000	0.718000	0.076046
Lower Middle Income Countries	0.650595	0.404	0.869	0.113829
Upper Middle Income countries	0.800642	0.465	0.925	0.082549
High Income Countries	0.858399	0.796	0.924	0.027139
Human Development index				
Low income Countries	0.423229	0.253000	0.528000	0.065191
Lower Middle Income Countries	0.643171	0.407	0.869	0.117278
Upper Middle Income countries	0.72992	0.576	0.832	0.051778
High Income Countries	0.799803	0.704	0.872	0.035496
Investment on Communication (Million US$)				
Low income Countries	651.1245	2.135000	6099.872	604.7769
Lower Middle Income Countries	715.9572	16.94	7543.89	1205.908
Upper Middle Income countries	4193.623	30.58	100215.9	14251.01
High Income Countries	1177.243	28.6	31921.4	3879.955
Investment on Software (Million US$)				
Low income Countries	554.9229	1.709000	15543.00	1030.914
Lower Middle Income Countries	319.6095	5.4	3198.98	515.794
Upper Middle Income countries	1152.587	1.2	23682.1	2422.186
High Income Countries	459.7442	5.4	2896.54	618.3724
Investment on Hardware (Million US$)				
Low income Countries	672.4617	4.937000	1729.947	449.9905
Lower Middle Income Countries	699.161	31.7	12462.2	1441.853

Upper Middle Income countries	2868.657	5.4	47652.6	7220.416
High Income Countries	1070.921	20.5	4528.6	1231.387
Investment on Services (Million US$)				
Low income Countries	776.9697	2.720000	12031.65	967.8901
Lower Middle Income Countries	518.8921	3	7598.98	1188.299
Upper Middle Income countries	2239.252	11.3	48683.5	6072.387
High Income Countries	1010.343	3	57596.57	4239.413
Individual using Internet (% of the population)				
Low income Countries	5.337253	0.015264	26.71835	6.523414
Lower Middle Income Countries	15.70833	0.047023	76.12452	16.98635
Upper Middle Income countries	30.31686	0.114097	80.86472	22.70829
High Income Countries	44.90934	2.210692	98.64343	25.90325
Mobile Cellular Subscribers (per 100 people)				
Low income Countries	34.64806	0.018092	139.5290	33.87394
Lower Middle Income Countries	61.73471	0.024533	164.4406	45.65504
Upper Middle Income countries	80.32366	0.499948	180.4934	48.52424
High Income Countries	100.4848	6.658398	210.0492	48.43499
Fixed Telephone Subscribers (per 100 people)				
Low income Countries	1.050174	0.065294	4.802064	1.082748
Lower Middle Income Countries	6.787049	0.071725	29.97783	7.427991
Upper Middle Income countries	17.43937	0.190299	48.10332	9.635989
High Income Countries	23.02877	8.706189	43.14811	9.041754

Mean= Mean Value, Max=Maximum, Min=Minimum, Std.Dev=Standard Deviation

Description of the Variables

HDI is consisting of three components such as living standard, education and health. GDP is used to assessed living standard of a country, literacy rate and the level of school enrollment are used to assess the educational standard and life expectancy is used for assessing the health (Kim et al., 2008). GDP per Capita which is proxy of standard of living, Education index (EI), life expectancy index (LEI) and Human Development index (HDI) are used as dependent variables, investment on ICT related components such as communication, software, hardware & services and three controlled variable such as individual using internet, Mobile cellular subscribers and fixed telephone subscribers are used as explanatory variable. The selection of these controlled variables are taken from the previous study. It is explored that, these controlled variable has impact on the components of HDI in sub Saharan Africa (Andrés et al., 2017).

Investment on communication refer to the total spending on local and long wire line and wireless system, investment on software consisting the spending on database system, software packages and programming tools, investment on hardware refer to the spending ICT related hardware and investment on services related to amount spending on human capital, software customization and ICT related expenses (Bankole et al., 2011)

Model Specification

ARDL approach is used to explore the impact of ICT investment on the different components of HDI because some variables are stationary at level I(0) and some are stationary at first difference I(1). ARDL model is the most general dynamic unrestricted model in econometric literature. It handle the problems of misspecification and autocorrelation and come up with a most appropriate interpretable model (Ghouse et al., 2018). ARDL is used to explore a long-run relationship between the dependent and independent variables in small sample size (Nkoro & Uko, 2016). The previous study used this method to investigate the impacts of various dimensions of ICT investment on components of human development in low, middle and high income countries (Bankole et al., 2011).

Model: 1

$GDP = f(CI, SI, HI, SerI, Uint, MCS, FTS)$…….. (1)

$\Delta GDP_t = \alpha_o + \beta_1 logCI_{t\text{-}i} + \beta_2 logSI_{t\text{-}i} + \beta_3 logHI_{t\text{-}i} + \beta_4 logSerI_{t\text{-}i} + \beta_5 logIUint_{t\text{-}i} + \beta_6 logMCS_{t\text{-}i} + \beta_7 logFTS_{t\text{-}i} + \mathcal{E}_t + \lambda_1 logCI_{t\text{-}i} + \lambda_2 logSI_{t\text{-}i} + \lambda_3 logHI_{t\text{-}i} + \lambda_4 logSerI_{t\text{-}i} + \lambda_5 logIUint_{t\text{-}i} + \lambda_6 logMCS_{t\text{-}i} + \lambda_7 logFTS_{t\text{-}i} + \mu_t$……………… (2)

Model: 2

$EInd = f(CI, SI, HI, SerI, IUint, MCS, FTS)$…………… (3)

$\Delta EInd_t = \alpha_o + \beta_1 logCI_{t\text{-}i} + \beta_2 logSI_{t\text{-}i} + \beta_3 logHI_{t\text{-}i} + \beta_4 logSerI_{t\text{-}i} + \beta_5 logIUint_{t\text{-}i} + \beta_6 logMCS_{t\text{-}i} + \beta_7 logFTS_{t\text{-}i} + \mathcal{E}_t + \lambda_1 logCI_{t\text{-}i} + \lambda_2 logSI_{t\text{-}i} + \lambda_3 logHI_{t\text{-}i} + \lambda_4 logSerI_{t\text{-}i} + \lambda_5 logIUint_{t\text{-}i} + \lambda_6 logMCS_{t\text{-}i} + \lambda_7 logFTS_{t\text{-}i} + \mu_t$………….(4)

Model: 3

$LEI = f(CI, SI, HI, SerI, IUint, MCS, FTS)$……………….. (5)

$\Delta LEI_t = \alpha_o + \beta^1 logCI_{t\text{-}i} + \beta^2 logSI_{t\text{-}i} + \beta^3 logHI_{t\text{-}i} + \beta^4 logSerI_{t\text{-}i} + \beta^5 logIUint_{t\text{-}i} + \beta^6 logMCS_{t\text{-}i} + \beta^7 logFTS_{t\text{-}i} + \mathcal{E}_t + \lambda^1 logCI_{t\text{-}i} + \lambda^2 logSI_{t\text{-}i} + \lambda^3 logHI_{t\text{-}i} + \lambda^4 logSerI_{t\text{-}i} + \lambda^5 logIUint_{t\text{-}i} + \lambda_6 logMCS_{t\text{-}i} + \lambda_7 logFTS_{t\text{-}i} + \mu_t$………………….(6)

Model: 4

$HDI = f(CI, SI, HI, SerI, IUint, MCS, FTS)$…………… (7)

$\Delta HDI_t = \alpha_o + \beta_1 logCI_{t\text{-}i} + \beta_2 logSI_{t\text{-}i} + \beta_3 logHI_{t\text{-}i} + \beta_4 logSerI_{t\text{-}i} + \beta_5 logIUint_{t\text{-}i} + \beta_6 logMCS_{t\text{-}i} + \beta_7 logFTS_{t\text{-}i} + \mathcal{E}_t + \lambda_1 logCI_{t\text{-}i} + \lambda_2 logSI_{t\text{-}i} + \lambda_3 logHI_{t\text{-}i} + \lambda_4 logSerI_{t\text{-}i} + \lambda_5 logIUint_{t\text{-}i} + \lambda_6 logMCS_{t\text{-}i} + \lambda_7 logFTS_{t\text{-}i} + \mu_t$………………(8)

Whereas

GDP = Gross Domestic Product per Capita
EI = Education index
LEI= Life Expectancy Index
HDI = Human Development Index
CI = Communication investment
SI = Software Investment
HI = Hardware Investment
SerI = Services Investment
IUint = Individual using internet
MCS = Mobile cellular subscribers
FTS = Fixed telephone subscribers

In the first part of the above equations, α_o is intercept term while β_i and $\mathcal{E}_t$ express the short-run dynamics of model. The 2nd part explains the long-run relationship. $H_o=\lambda_1= \lambda_2= \lambda_3= \lambda_4= \lambda_5= \lambda_6= \lambda_7=0$, it means that there is no presence of long-run relationship among the variables.

Econometric Procedure

Following steps have been employed in the econometric procedure: (a) CSD test (b) unit root test analysis (c) cointegration test analysis (d) regression analysis.

a) Cross section Dependence Test (CD)

Cross-sectional dependence exists in panel data. It is due to the existence of common shocks, which is the parts of error term but uncorrelated with the regressors (Robertson & Symons, 2000). To avoid these issues, it is compulsory to check the stationary and CSD. If CSD occurs, the results are unreliable and biased (H. Pesaran, 2004). In this study, three CD tests are applied to check the cross-sectional dependence such as Pesaran's (2004) CD test, Friedman's (1937) CD test, and Frees (1995) CD test (De Hoyos & Sarafidis, 2006).

Pesaran (2004) has proposed CD test as follows:

$$\text{CD} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \sim N(0,1) i,j \quad (1)$$

Whereas $^\wedge\rho_{ij}$ is residual of pairwise correlation sample, estimated by linear regression equation. The null hypotheses of no CSD, CD→N (0, 1) for N is relatively small and T is adequately large (M. H. Pesaran, 2004).

b) Friedman's test:

Friedman (1937) suggested a nonparametric test. It is based on Spearman's rank correlation coefficient. It is computed on the basis of ranking (r_i,1, . . . , r_i,) and its average rank is (T + 1⁄2) (Friedman, 1937).

$$r_{ij} = r_{ji} = \frac{\sum_{t=1}^{T}\{r_{i,t} - (T+1/2)\}\{r_{j,t} - (T+1/2)\}}{\sum_{t=1}^{T}\{r_{i,t} - (T+1/2)\}^2} \quad (2)$$

Average Spearman's correlation is given as:

$$R_{\text{ave}} = \frac{2}{N(N-1)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\acute{r}^2{}_{\text{ij}} \quad (3)$$

Where r_{ij} is used for sample estimation of the residuals. Large values of R_{ave} indicate the presence of non-zero cross-sectional correlations. The CD and R_{ave} have some common features. Both tests involv in the sum of the pairwise correlation coefficients of the residual matrix rather than the sum of the squared correlations.

c) Frees Test

Frees (1995) proposed CD test to check the cross-sectional dependency in data. This statistics is based on the following equations:

$$R_{ave}^2 = \frac{2}{N(N-1)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{r}_{ij}^2 \quad (4)$$

$$FRE = N\{R_{ave}^2 - (T-1)^{-1}\} \xrightarrow{d} Q$$
$$= a(T)\{x_{1,T-1}^2 - (T-1)\} + b(T)\{x_{2,T(T-3)/2}^2 - T(T-3)/2\} \quad (5)$$

Where $x^2{}_{1,T-1}$ and $x^2{}_{2,T(T-3)/2}$ are independently random variables with T − 1 and T (T − 3) /2 degrees of freedom respectively. Thus the null hypothesis is rejected if $R^2_{ave} > (T-1)^{-1} + Q_q/N$(Frees, 1995).

Panel Unit Root Tests

After checking the CSD in data, further tests are required to check the presence of stationarity. Two types of unit root tests have been developed in panel, such as first and second generation unit root tests. The first generation test is used if the assumption follows that data is independent and identically distributed across the variables (Levin, Lin et al., 2002). It is not applicable if cross-sectional correlation occurs in the data and autoregressive parameters are considered being identical across the panel. Second generation unit root test has two tests: CIPS and CADF, being two main approaches of 2nd generation tests. The first approach proposes non-linear instrumental variable approach to solve the problem of nuisance parameter generated due to the cross-sectional dependency (Chang et al., 2004). The 2nd approach relies on the factor structure approach (Phillips & Sul, 2003).

The second unit root test rejected the null hypotheses that there exists no cross-sectional dependency. If cross-sectional dependence occurs in data, CIPS 2nd generation unit root test is used in the analysis (Baltagi et al., 2007). This test encounters problem of heterogeneity. The main advantage of the test is that small number of unobserved common factors is used cross (Breitung & Das, 2005). Pesaran (2003) suggested methodology in a CADF regression (Lewandowski, 2007). It is representing by the following formula:

$$\Delta Y_{it} = \alpha_i + \beta_i Y_{i,t-1} + \sum_{j=1}^{pi} \gamma_{ij} \Delta Y_{i,t-1} + d_i \tau + c_i \bar{Y}_{t-1} + \sum_{j=0}^{pi} \Phi_{ij} \Delta \bar{Y}_{i,t-j} + \varepsilon_{it}$$

$$\bar{Y}_t = N^{-1} \sum_{j=1}^{N} Y_{jt} \qquad \Delta \bar{Y}_{i,t} = N^{-1} \sum_{j=1}^{N} \Delta Y_{jt}$$

Where e_{it} is the error term. Let $CADF_i$ be the ADF measurements for the i-th cross-sectional unit given by the t-proportion of the OLS estimates of β_i in the CADF regression.

Long-run Cointegration Tests

For long-run cointegration relationship among the integrated variable, three tests such as kao, Pedroni and westerlund are used. Cointegration test was originally proposed by Kao (1997) and Pedroni (1997) under the null hypothesis of no cointegration. The Kao (1997) test for cointegration is used for only homogeneous panels while Pedroni (1997) test is used for both, homogeneous as well as heterogeneous panel for testing coinetgration. Kao test used Augmented Dickey–Fuller test to estimate the cointegration among the variables. No cointegration among the variables is null hypothesis of Kao cointegration test. If null hypothesis is rejected, then cointegration exist in the panel data. ADF probability value <0.05 means that panel data is cointegrated (Kao, 1999). Pedroni used the Dicky-Fuller (DF) estimation and Phillips Perron test, while McCoskey used ADF estimation for unit roots (Pedroni, 1999).

Regression Analysis

ARDL model is proposed by Granger (1981), Engle & Granger (1987) and Johansen and Juselius (1990). It is used for long-run relationship between the series of non-stationary panel data. Granger and Engle & Granger cointegration analysis is applicable for the same integrated orders while in Johansen and Juselius cointegration technique is used for integrated of different orders (Granger, 1981); (Engle & Granger, 1987); (Johansen & Juselius, 1990); (Pesaran et al., 1999). ARDL model is very helpful to eliminate the problem of standard cointegration analysis which needs the classification of the variables of order I(0) and I(1). The pre-testing of the variables does not require in bound cointegration testing procedure included in the model for unit roots (Nkoro & Uko, 2016). The simple ARDL model is as under:

$$y_t = \beta_0 + \beta_1 y_{t-1} + ... + \beta_p y_{t-p} + \alpha_0 x_t + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + ... + \alpha_q x_{t-q} + \varepsilon_t$$

Where ε_t is disturbance term. y_t is lagged values of itself. x is explanatory variables. x_t is distributed lag value.

Result and Discussion

Cross-sectional Dependence (CD)

[Table 2 and 3] explains the results of cross-sectional dependency test. The results show the presence of CD in the four panels of the developing countries. Pesaran CD test, Friedman CD test and Frees test were applied to check the presence of CD in data. These three CD test rejects the null hypothesis of cross-sectional independence. CD test results are highly significance. Pesaran and Friedman's tests reject the null of cross-sectional independence because probability value of both is < 0.05. Frees test also reject the null hypothesis of no cross-sectional dependence. Frees test results show that T≤ 30, Frees' test provides the critical values for α= 0.10, α= 0.05 and α= 0.01 from the Q distribution value. Frees statistic is larger than the critical value with at least α= 0.01 (De Hoyos & Sarafidis, 2006).

Panels

Low.IC = Low Income Countries
LMIC = Lower Middle Income Countries
Up.MIC = Upper Middle Income Countries
High.IC = High income countries

Table 2: CD test Results:

CD Test	**Low.IC**		**LMIC**		**Up.MIC**		**High.IC**	
	Test stat.	Prob.	Test stat.	Prob.	Test stat.	Prob.	Test stat.	Prob.
Pesaran CD	6.313	0.000	2.954	0.000	19.111	0.000	3.615	0.000
Friedman CD	45.699	0.000	46.446	0.000	108.686	0.000	46.219	0.001

Table 3: frees test results

CD Test	**Low.IC**	**LMIC**	**Up.MIC**	**High.IC**
	Frees' cross-sectional independence = 2.997	Frees' cross-sectional independence =4.872	Frees' cross-sectional independence=4.519	Frees' cross-sectional independence=0.916
Frees CD test	Crt. value	Crt. Value	Crt.value	Crt. value
	0.136*	0.136*	0.136*	0.136*
	0.178**	0.178**	0.178**	0.178**
	0.260***	0.260***	0.260***	0.260***

Crt. = critical. a) Significance at 1 % , b) Significance at 5%, c) Significance at 10%

Panel unit root test results:

Table 4, 5, 6 and 7 explains unit root test analysis results. CIPS test shows mixed results at level form by using only intercept and Intercept & trend but some variable are stationary at level and some are stationary at first difference. [Table 3] shows CIPS unit root test result at level form by using only intercept at level. GDP per Capita (log GDP) is non-stationary at level in lower middle income countries panel, life expectancy index (log LEI) is non-stationary at level in lower and lower middle income countries. Education index (log EI) is non-stationary in high income countries. Human Development Index (log HDI), software investment (log SI) and hardware investment (log HI) are non-stationary in lower middle and high income countries. Individual using internet (log I.UInt) is non-stationary in lower, lower middle and high income countries. Fixed telephone subscriber (log FTS) is non-stationary in all panels. Table 3.1 shows that all variable are stationary at first difference by using only intercept. Table 3.2 shows mixed results by using intercept & trend at level. Mostly variables are stationary at level form in four panels.GDP per capita (log GDP) is non-stationary in upper middle income countries. Life expectancy index (log LEI) and fixed telephone subscribers (log FTS) are non-stationary in all panels. Education index (log EI) is non-stationary in lower, lower middle and high income countries. Software investment (log SI) is non-stationary in all panels except lower income countries, hardware investment (HI) is non-stationary in lower middle and high income countries while individual using internet (log I.Uint) is non- stationary in lower income countries. Table 3.4 shows that all variable are stationary at first difference by using intercept and trend. In the presence of CD, we used kao and Pedroni test to check the cointegration among the variables in long-run (Kao, 1999).

Table 4: CIPS unit root test: Only intercept (at level):

Variable		**Low.IC**	**LMIC**	**Up.MIC**	**High.IC**
		CIPS	CIPS	CIPS	CIPS
Log GDP		-3.091[a]	-2.036	-2.090[c]	-2.752[a]
Log LEI		-2.103	-1.996	-2.831[a]	-2.409[b]
Log EI		-2.226[b]	-3.075[a]	-2.494[a]	-1.581
Log HDI		-2.771[a]	-1.152	-2.402[a]	-1.924
LogCI		-2.625[a]	-3.094[a]	-2.700[a]	-3.094[a]
LogSI		-2.805[a]	-1.622	-2.171[b]	-1.674
LogHI		-4.219[a]	-1.420	-2.236[b]	-1.420
LogSerI		-3.257[a]	-2.359[b]	-3.153[a]	-2.359[b]
LogIUint		-1.712	-1.793	-2.354[a]	-1.793
LogMCSub		-3.207[a]	-3.389[a]	-2.901[a]	-3.115[a]
Log FTS		-1.493	-1.306	-1.120	-1.120
Critical Values	1%	-2.47[a]	-2.40[a]	-2.32[a]	-2.60[a]
	5%	-2.26[b]	-2.21[b]	-2.15[b]	-2.34[b]
	10%	-2.14[c]	-2.10[c]	-2.07[c]	-2.21[c]

a) Significance at 1 %, b) Significance at 5%, c) Significance at 10%

Table 5: Case.2 only intercept (at First Difference):

Variable	**Low.IC**	**LMIC**	**Up.MIC**	**High.IC**
	CIPS	CIPS	CIPS	CIPS
Log GDP	-4.336[a]	-3.489[a]	-3.258[a]	-2.995[a]
Log LEI	-2.675[a]	-3.305[a]	-3.284[a]	-4.024[a]
Log EI	-3.641[a]	-4.605[a]	-3.764[a]	-3.171[a]
Log HDI	-4.093[a]	-2.915[a]	-3.538[a]	-3.692[a]
LogCI	-4.750[a]	-4.560[a]	-4.245[a]	-4.560[a]
LogSI	-4.126[a]	-3.463[a]	-3.824[a]	-3.463[a]

LogHI		-4.470[a]	-3.819[a]	-4.662[a]	-3.819[a]
LogSerI		-4.321[a]	-3.987[a]	-3.584[a]	-3.987[a]
LogIUint		-3.640[a]	-4.321[a]	-3.851[a]	-4.414[a]
LogMCSub		-4.572[a]	-3.775[a]	-3.709[a]	-3.945[a]
Log FTS		-3.502[a]	-2.856[a]	-3.416[a]	-3.416[a]
Critical Values	1%	-2.47[a]	-2.40[a]	-2.32[a]	-2.60[a]
	5%	-2.26[b]	-2.21[b]	-2.15[b]	-2.34[b]
	10%	-2.14c	-2.10c	-2.07c	-2.21c

a) Significance at 1 %, b) Significance at 5%, c) Significance at 10%

Table 6: Case.3 intercept and trend (at level)

Variable		Low.IC	LMIC	Up.MIC	High.IC
		CIPS	CIPS	CIPS	CIPS
Log GDP		-3.356[a]	-2.657[c]	-2.525	-3.132[b]
Log LEI		-2.016	-2.590	-2.491	-2.620
Log EI		-2.267	-3.370[a]	-2.187	-1.392
Log HDI		-2.740[c]	-1.317	-2.248	-1.317
LogCI		-3.300[a]	-3.420[a]	-2.829[c]	-3.420[a]
LogSI		-3.061[a]	-2.114	-2.531	-2.114
LogHI		-4.062[a]	-1.879	-3.134[a]	-1.879
LogSerI		-3.666[a]	-2.891[b]	-3.007[a]	-2.891[b]
LogIUint		-1.887	-2.840[b]	-2.802[b]	-2.840[c]
LogMCSub		-3.776[a]	-3.389[a]	-3.250[a]	-3.553[a]
Log FTS		-2.273	-1.648	-1.784	-1.784
Critical values	1%	-3.01[a]	-2.92[a]	-2.83[a]	-3.15[a]
	5%	-2.78[b]	-2.73[b]	-2.67[b]	-2.88[b]
	10%	-2.67[c]	-2.63[c]	-2.58[c]	-2.74c

a) Significance at 1 %, b) Significance at 5%, c) Significance at 10%

Table 7: Case.4 intercept and trend (at First Difference):

Variable		Low.IC	LMIC	Up.MIC	High.IC
		CIPS	CIPS	CIPS	CIPS
LogGDP		-4.378[a]	-3.318[a]	-3.191[a]	-2.464[a]
LogLEI		-3.356[a]	-3.252[a]	-3.493[a]	-4.211[a]
LogEI		-3.459[a]	-4.707[a]	-4.159[a]	-3.367[a]
LogHDI		-4.207[a]	-3.867[a]	-3.857[a]	-3.867[a]
LogCI		-4.700[a]	-4.526[a]	-4.199[a]	-4.526[a]
LogSI		-4.431[a]	-4.118[a]	-4.180[a]	-4.134[a]
LogHI		-4.847[a]	4.305[a]	-4.307[a]	-4.305[a]
LogSerI		-4.804[a]	-4.314[a]	-4.248[a]	-4.314[a]
LogIUint		-3.954[a]	-4.238[a]	-4.024[a]	-4.238[a]
LogMCSub		-4.645[a]	-3.916[a]	-3.623[a]	-3.436[a]
logFTS		-3.572[a]	-3.187[a]	-3.516[a]	-3.516[a]
Critical Values	1%	-3.01[a]	-2.92[a]	-2.83[a]	-2.15[a]
	5%	-2.78[b]	-2.73[b]	-2.67[b]	-2.88[b]
	10%	-2.67[c]	-2.63[c]	-2.58[c]	-2.74[c]

a) Significance at 1 %, b) Significance at 5%, c) Significance at 10%

Panel cointegration test results:

Table 8 shows kao test for cointegration results while table 9, 10, 11, and 12 shows Pedroni cointegration test results in lower, lower middle, upper and high income countries respectively. Results shows the presence of cointegration in four panels of developing countries. The null hypothesis that no cointegration was rejected due to significant test statistics. The long-run association established among the variables in four panels.

a) Kao Test For Cointegration

Table 8: Kao Test for Cointegration:

Components	Test	Statistics	P-value
Lower Income Countries			
Log GDP	Augmented Dicky-Fuller t	-5.750	0.000
Log LEI	Augmented Dicky-Fuller t	-1.707	0.043
Log EI	Augmented Dicky-Fuller t	-3.074	0.001
Log HDI	Augmented Dicky-Fuller t	-2.962	0.001
Lower Middle Income Countries			
Log GDP	Augmented Dicky-Fuller t	-4.012	0.000
Log LEI	Augmented Dicky-Fuller t	-3.988	0.000
Log EI	Augmented Dicky-Fuller t	-3.688	0.000
Log HDI	Augmented Dicky-Fuller t	-3.459	0.000
Upper Middle Income Countries			
Log GDP	Augmented Dicky-Fuller t	-5.376	0.000
Log LEI	Augmented Dicky-Fuller t	-3.980	0.000
Log EI	Augmented Dicky-Fuller t	-4.049	0.000
Log HDI	Augmented Dicky-Fuller t	-5.965	0.000
High Income Countries			
Log GDP	Augmented Dicky-Fuller t	-3.721	0.000
Log LEI	Augmented Dicky-Fuller t	-1.865	0.031
Log EI	Augmented Dicky-Fuller t	-3.936	0.000
Log HDI	Augmented Dicky-Fuller t	-2.282	0.011

B) Pedroni test for cointegration

Lower Income Countries

Table 9: Pedroni test for Cointegration:

Components	Test	Statistic	p-value
Log GDP	MPP test	5.102	0.000
	PP test	-3.873	0.000
	ADF test	-1.870	0.030
Log LEI	MPP test	4.013	0.000
	PP test	-1.607	0.054
	ADF test	-0.955	0.169
Log EI	MPP test	4.338	0.000
	PP test	-1.090	0.137
	ADF test	-1.988	0.023
Log HDI	MPP test	4.606	0.000
	PP test	-0.494	0.310
	ADF test	-1.328	0.037

MPP = Modified Phillips Perron, PP = Phillips Perron, ADF = Augmented Dicky-Fuller

Lower Middle Income Countries

Table 10: pedroni test for Cointegration:

Components	Test	Statistic	p-value
Log GDP	MPP test	6.1110	0.000
	PP test	-3.8042	0.000
	ADF test	-1.978	0.032
Log LEI	MPP test	5.3025	0.000
	PP test	-3.0537	0.001
	ADF test	-2.3204	0.010
Log EI	MPP test	3.6884	0.000
	PP test	-9.5922	0.000
	ADF test	-8.5266	0.000
Log HDI	MPP test	5.7480	0.000
	PP test	-1.1431	0.126
	ADF test	-1.6809	0.046

Upper Middle Income Countries

Table 11: Pedroni test for Cointegration:

Components	Test	t-Statistic	p-value
Log GDP	MPP test	6.0805	0.000
	PP test	-1.7976	0.036
	ADF test	-1.8470	0.032
Log LEI	MPP test	5.6279	0.000
	PP test	-0.6637	0.253
	ADF test	-2.8274	0.002
Log EI	MPP test	4.8458	0.000
	PP test	-4.1610	0.000
	ADF test	-4.3072	0.000
Log HDI	MPP test	5.5182	0.000
	PP test	-3.1006	0.001
	ADF test	-2.6342	0.004

High Income Countries

Table 12: Pedroni test for Cointegration:

Components	Test	t-Statistic	p-value
Log GDP	MPP test	4.0752	0.000
	PP test	-0.8857	0.187
	ADF test	-1.6603	0.048
Log LEI	MPP test	4.1194	0.000
	PP test	0.5779	0.2817
	ADF test	2.3527	0.004
Log EI	MPP test	3.829	0.000
	PP test	-1.622	0.054
	ADF test	-1.856	0.014
Log HDI	MPP test	3.5699	0.000
	PP test	-2.5552	0.005
	ADF test	-3.0107	0.001

Autoregressive-Distributed Lag (ARDL) Regression Model:

A) **Dependent variable: Log GDP**

Table 13: Long-run and short-run Results:

Variable	Low.IC		LMIC		Up.MIC		High.IC	
	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
Long-run Equation Results								
LogCI	0.169	0.000	0.244	0.004	0.431	0.000	0.099	0.000
LogSI	0.106	0.000	0.693	0.000	0.046	0.374	0.321	0.000
LogHI	0.150	0.000	1.328	0.000	0.522	0.000	-0.032	0.379
LogSI	-0.023	0.336	0.032	0.611	-0.647	0.000	0.271	0.000
LogIUint	0.082	0.000	0.080	0.029	0.216	0.001	-0.049	0.487
LogMCS	0.155	0.000	0.327	0.000	0.938	0.000	0.819	0.000
LogFTS	0.055	0.005	0.265	0.000	0.479	0.000	-0.178	0.316
Short-run Equation Results								
ECM	-0.458	0.000	-0.194	0.002	-0.121	0.007	-0.447	0.000
D(LogCI)	-0.000	0.993	0.103	0.069	0.263	0.000	0.128	0.032
D(LogSI)	0.052	0.175	-0.056	0.782	0.033	0.796	0.342	0.012
D(LogHI)	0.007	0.894	-0.299	0.139	-0.081	0.645	0.245	0.152
D(LogSerI)	-0.067	0.042	0.152	0.166	0.172	0.055	-0.140	0.117
D(LogIUint)	-0.055	0.296	0.107	0.000	0.087	0.159	0.004	0.955
D(LogMCS)	-0.063	0.393	0.064	0.232	0.163	0.028	-0.063	0.587
D(LogFTS)	-0.027	0.686	-0.164	0.089	0.290	0.354	0.186	0.637
C	0.980	0.001	0.018	0.707	0.096	0.005	1.202	0.000

a) Significance at 1 %, b) Significance at 5% , c) Significance at 10%

B) **Dependent variable: Log Education Index (EI)**

Table 14: Long-run Equation Results:

Variable	Low.IC		LMIC		Up.MIC		High.IC	
	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
Long-run Equation Results								
LogCI	0.097	0.000	0.093	0.016	0.073	0.000	0.280	0.000
LogSI	0.045	0.000	0.086	0.012	0.031	0.005	0.242	0.000
LogHI	0.059	0.001	0.057	0.000	0.010	0.034	-0.009	0.602
LogSerI	0.036	0.002	-0.022	0.318	-0.019	0.262	0.164	0.000
LogIUint	0.005	0.624	0.027	0.000	0.059	0.000	0.066	0.009
LogMCS	0.011	0.150	0.033	0.033	-0.015	0.092	0.249	0.000
LogFTS	-0.100	0.000	-0.001	0.271	0.036	0.003	-0.279	0.542
Short-run Equation Results								
ECM	-0.180	0.026	-0.392	0.000	-0.161	0.000	-0.061	0.041
D(LogCI)	-0.021	0.074	0.006	0.336	0.011	0.297	-0.039	0.143
D(LogSI)	0.017	0.354	0.043	0.093	0.011	0.317	0.011	0.430
D(LogHI)	0.002	0.765	-0.039	0.118	-0.003	0.806	-0.013	0.510
D(LogSerI)	0.007	0.298	-0.018	0.287	-0.005	0.636	0.000	0.957
D(LogIUint)	-0.004	0.516	-0.000	0.713	-0.019	0.001	0.017	0.075
D(LogMCS)	0.0005	0.996	0.014	0.037	-0.009	0.440	-0.002	0.763
D(LogFTS)	0.038	0.128	-0.006	0.204	0.015	0.665	0.003	0.918
C	-0.122	0.045	-0.133	0.000	0.008	0.014	0.005	0.231

a) Significance at 1 %, b) Significance at 5% , c) Significance at 10%

C) **Dependent variable: Log Life Expectancy Index (LEI)**

Table 15: Long-run and short-run Results:

Variable	Low.IC		LMIC		Up.MIC		High.IC	
	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
Long-run equation results								
LogCI	0.017	0.000	0.004	0.310	0.011	0.000	0.024	0.000
LogSI	0.022	0.111	0.066	0.000	0.009	0.000	0.001	0.794
LogHI	-0.018	0.261	0.019	0.006	0.004	0.095	0.064	0.002
LogSerI	0.039	0.000	0.067	0.000	0.061	0.000	0.106	0.001
LogIUint	0.034	0.004	0.081	0.001	0.024	0.000	0.086	0.011
LogMCS	-0.020	0.072	0.012	0.000	0.097	0.000	0.007	0.219
LogFTS	0.013	0.125	0.016	0.000	-0.000	0.362	0.013	0.295
Short-run equation results								
ECM	-0.0137	0.0000	-0.1266	0.0232	-0.0774	0.0014	-0.0480	0.0550
D(LogCI)	-0.0020	0.1209	0.0309	0.2749	-0.0008	0.3891	-0.0008	0.0602
D(LogSI)	0.0005	0.6529	-0.0032	0.8658	0.0011	0.5479	0.0019	0.0562
D(LogHI)	0.0007	0.4212	-0.0186	0.0048	0.0007	0.6036	0.0014	0.2637
D(LogSerI)	0.0001	0.6278	-0.0091	0.1928	0.0012	0.3421	-0.0025	0.0105
D(LogIUint)	-0.0010	0.0296	-0.0098	0.4074	-0.0011	0.1633	0.0025	0.0404
D(LogMCS)	0.0007	0.5211	0.0217	0.2381	-0.0012	0.2889	0.0004	0.6700
D(LogFTS)	0.0462	0.1473	-0.0060	0.1950	0.0173	0.6810	0.0039	0.8375
C	-0.1026	0.0357	-0.0265	0.0184	-0.0062	0.5154	0.0003	0.8348

a) Significance at 1 %, b) Significance at 5% , c) Significance at 10%

D) **Dependent variable: Log Human Development Index (HDI)**

Table 16: Long-run and short-run Results:

Variable	Low.IC		LMIC		Up.MIC		High.IC	
	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
Long-run equation results								
LogCI	0.111	0.000	0.028	0.000	0.060	0.000	-0.011	0.266
LogSI	0.127	0.000	0.011	0.187	-0.001	0.621	0.014	0.020
LogHI	0.261	0.000	0.159	0.000	0.024	0.000	-0.000	0.897
LogSerI	0.022	0.094	0.028	0.000	0.046	0.000	0.012	0.010
LogIUint	0.071	0.000	0.028	0.000	0.002	0.123	0.054	0.000
LogMCS	0.124	0.000	0.038	0.000	0.016	0.000	-0.004	0.584
LogFTS	0.090	0.000	0.008	0.131	0.008	0.053	0.100	0.000
Short-run equation results								
ECM	-0.0159	0.0593	-0.3140	0.0066	-0.2028	0.0015	-0.1219	0.0198
D(LogCI)	0.0033	0.4023	0.0454	0.7444	0.0572	0.5574	-0.0050	0.3132
D(LogSI)	0.0069	0.3618	-0.0179	0.1172	-0.0071	0.0355	0.0109	0.0219
D(LogHI)	0.0044	0.4444	-0.0507	0.7136	0.0133	0.0007	0.0039	0.5018
D(LogSerI)	0.0008	0.8586	0.0684	0.0972	-0.0007	0.8704	-0.0032	0.4213
D(LogIUint)	0.0064	0.1144	0.0168	0.8414	-0.0055	0.3768	0.0008	0.8113
D(LogMCS)	0.0117	0.1332	0.0273	0.5396	-0.0027	0.6671	-0.0004	0.9380
D(LogFTS)	0.0060	0.6247	-0.0211	0.5688	-0.0012	0.8015	0.0137	0.4927
C	-0.1026	0.0357	-0.0928	0.4243	0.0200	0.2853	0.1583	0.0618

a) Significance at 1 %, b) Significance at 5% , c) Significance at 10%

Regression Analysis

Table 13 shows regression analysis results of the components of HDI in four panels of developing countries. Regression analysis explore the relationship between components of Human development such as standard of living (GDP), life expectancy index (LEI), Education index (EI), Human Development Index (HDI) and its selected explanatory variable such as communication investment (CI), software investment (SI), hardware investment (HI), Services investment (SerI), individual using internet (IUint), Mobile cellular subscribers (MCS) and fixed telephone subscribers (FTS) in developing countries. We investigated long-run association by applying the ARDL model proposed by Pesaran (2001) (Pesaran et al., 2001).

Table 14 explores the long and short-run relationship between the GDP and explanatory variable mentioned in the equation 3.2. The result shows that communication investment and software investment are positively significant in Low.IC, LMIC, Up.MIC and High.IC. It is found that, 1 % increase in the communication investment will increase the GDP, 0.169 % in Low.IC, 0.244 % in LMIC, 0.431% in Up.MIC and 0.099 % in High.IC. The software investment is statistically significant at 1% level of significance in Low.IC, LMIC and High.IC while insignificance in Up.MIC. The results explain that, 1 % increase in software investment will increase GDP, 0.106 % in lower, 0.693 % in LMIC and 0.099 % in High.IC. Literature shows that software has positive impact on GDP (Powell & Dent-Micallef, 1997). The hardware investment is positively significance in lower, LMIC and Up.MIC while insignificance in High.IC. It is found that 1 % in hardware investment will increase the GDP, 0.150 % in lower, 1.328 % in LMIC and 0.522 % in Up.IC. The services investment is significance in Up.MIC but statistically negative and positively significance in High.IC at 1% level of significance. The results shows that 1 % increase in services investment will increase 0.271 % GDP in High.IC but decrease 0.647 % GDP in Up.MIC. The previous results shows that investment in communication, software, hardware and services investment have positive and negative impact on GDP and productivity in developing countries (Kim et al., 2008) ; (Loveman, 1994); (Powell & Dent-Micallef, 1997). The individual using internet and fixed telephone subscribers are positively significance in low.IC, LMIC and Up.MIC while insignificance in High.IC. The result shows that 1 % increase in internet users will increase the 0.082 % GDP in Lower, 0.080 % in LMIC and 0.216 % in Up.MIC. 1 % increase in internet users will increase the 0.082 % GDP in lower, 0.080 % in LMIC and 0.216 % in UP.MIC. 1 % increase in fixed telephone subscribers will increase the 0.055% GDP in low.IC 0.265, % in LMIC and 0.479 % in Up.MIC. The mobile cellular subscribers are positively significance in all panels of the developing countries. it is explore that 1 % increase in mobile cellular subscribers ratio will increase GDP, 0.155 % in Low.IC, 0.327 % in LMIC, 0.938 % Up.MIC and 0.819 % in High.IC. The previous study shows that mobile phone penetration and internet penetration has positive impact on GDP (S. A. Asongu & Nwachukwu, 2016). The short-run equation results are presented in Table 5.1. The ECM coefficient shows the percentage of yearly convergence from short to long-run equilibrium (Khan et al., 2019). The results in the current study indicates that the ECM is statistically significant and negative value, which shows that there is a cointegration relationship between the model variables. The estimated value of ECM is −0.458 involving the adjustment speed of the long-run equilibrium in response to the imbalance caused by short-run shocks in the previous period.

Table 15 explains the relationship between the Education Index (EI) and explanatory variable mentioned in the equation 4. The result shows that investment in communication and investment in software are positively significant in all panels of the selected developing countries. The result shows that1 % increase in the communication investment will increase the education index (EI) level by 0.097 % in low.IC, 0.093% in LMIC, 0.073 % in Up.MIC and 0.280 % in High.IC. Its shows that communication investment has more impact in high income countries as compared to panels of the developing countries. The regression results regarding software explain that, 1 % increase in software investment will increase 0.045 % in Low.IC, 0.086 % in LMIC and 0.031 % in Up.MIC and 0.242 % in High.IC. The hardware investment is significance in Low.IC, LMIC and Up.MIC. It is explored that 1 % in hardware investment will increase the education index (EI) by.059 % in Low.IC, 0.057 % in LMIC and 0.010 % in Up.MIC. The services investment is statistically significance in Low.IC and High.IC at 1 % level of significance.

The result shows that 1 % increase in services investment will increase 0.036 % in EI in Low.IC and 0.164 % increase in EI in High.IC. The previous studies shows that ICT investment have positive impact on the education level in developing countries(Ngwenyama et al., 2006). The individual using internet (I.Uint) is statistically significance positively in LMIC, Up.MIC and High.IC. It is found that 1 % increase in I.Uint will increase the 0.027 % EI in LMIC, 0.059 % in Up.MIC and 0.066 % in High.IC. The mobile cellular subscribers are positively significance in LMIC and High.IC. The results shows that 1 % increase in mobile cellular subscribers ratio will increase EI by 0.033 % in LMIC and 0.249 % in High.IC. The fixed telephone subscribers (FTS) are statistically significance in Low.IC but have negative impact on EI while in Up.MIC. FTS is positively significance. The results explore that 1 % increase in FTS ratio will decrease EI by .0100 % in Low.IC and increase 0.036 % EI in Up.MIC. it is found that mobile phone penetration in Sub-Sahran Africa have positive impact on education level (S. Asongu & Nwachukwu, 2017). The short-run model elasticity are presented in Table 5.2. The result indicates that the ECM is statistically significant and negative. The ECM coefficient value is -0.180 % which shows the percentage of yearly convergence from short to long-run equilibrium.

Table 15 explains the long-run as well as short-run relationship between the Life Expectancy Index (LEI) and explanatory variable mentioned in the equation 3.6. It is explore that communication investment (CI) is positively significant in lower, Up.MIC and High.IC while insignificant in LMIC. The results shows that1 % increase in the CI will increase the life expectancy index (LEI) level by 0.017 % in lower income, 0.011 % in Up.MIC and 0.024 % in High.IC. The software investment (SI) is positively significant in LMIC and Up.MIC countries at the 1 % level of significant while insignificant in lower and High.IC. The regression result shows that 1 % increase in SI will increase LEI by 0.066 % in LMIC and 0.009 % in Up.MIC. The hardware investment (HI) is significance in High.IC at the level of 5 % significance. It is explored that 1 % increase in HI will increase LEI by 0.064 % in High.IC. The services investment (SerI) is statistically significance in all panels of the developing countries at 1 % level of significance. The results shows that 1 % increase in SerI will increase LEI by 0.03 % in Low.IC and 0.067 % increase in LMIC, 0.061 % in Up.MIC and 0.106 % in High.ICit is found that ICT investment have positive impact on health in African countries (Ngwenyama et al., 2006). The individual using internet (I.Uint) is statistically significance positively in all panels of the developing countries. It is observed that 1 % increase in I.Uint will increase LEI by 0.034 % in lower, 0.081 % in LMIC, 0.024 % in Up.MIC and 0.086 % in High.IC. The mobile cellular subscribers (MCS) are positively significance in LMIC and Up.MIC. The result shows that 1 % increase in MCS ratio will increase LEI by 0.012 % in lower mLMIC iddle and 0.097 % in Up.MIC. The fixed telephone subscribers (FTS) are statistically significance positively in LMIC at the 1 % level of significance. The result explores that 1 % increase in FTS ratio will increase LEI by 0.016 % in LMIC. ECM result in short-run equation is statistically significant and negative. The ECM coefficient value is -0.013 % at the level of 5 % significance which indicates that, the percentage of yearly convergence from short to long-run equilibrium.

Table 16 explains the relationship between the Human Development Index (HDI) and explanatory variable mentioned in the equation 3.8. It is found that communication investment (CI) is positively significant in lower, LMIC and upper middle income countries while insignificant in high income countries. The result shows that 1 % increase in the CI will increase HDI level by 0.111 % in lower income, 0.028 % in LMIC and 0.060 % in Up.MIC. The software investment (SI) is positively significant in lower and Hig.IC while insignificant in LMIC and Up.MIC. The result shows that 1 % increase in SI will increase HDI by 0.127 % in lower and 0.014 % in High.IC. The hardware investment (HI) is significance in lower, LMIC and Up.MIC at the level of 1 % significance. It is explored that 1 % increase in HI will increase HDI by 0.261 % in lower income, 0.159 % in LMIC and 0.024 % in Up.MIC. The services investment (SerI) is statistically significance in LMIC, Up.MIC and High.IC while insignificant in lower income countries. The result shows that 1 % increase in SerI will increase HDI by 0.028 % in LMIC, 0.046 % in Up.MIC and 0.012 % in high income countries. it is explore that ICT investment have positive impact on human development (Morawczynski & Ngwenyama, 2007); (Despotis, 2005); (Mansell, 1999). The individual using internet (I.Uint) is statistically significance positively in lower, LMIC and high income countries. It is found that 1 % increase in I.Uint will increase HDI by 0.071 % in lower, 0.281 % in LMIC, 0.054 % in High.IC. The mobile cellular subscribers (MCS) are positively significance in lower, LMIC and Up.MIC. The results shows that 1 % increase in MCS ratio will increase HDI by 0.124 % in lower, 0.038 % in LMIC and 0.016 % in Up.MIC. The fixed telephone subscribers (FTS) are statistically significance positively in lower, Up.MIC and high income countries. The result explores that 1 % increase in FTS ratio will increase by 0.090 % in lower, 0.008 % Up.MIC and 0.100 % high income countries. it is investigated that mobile phone, internet penetration and fixed telephone subscribers have impact on the human development in Sub-Saharan Africa (Asongu & Nwachukwu, 2017). ECM is statistically significant and negative. The ECM coefficient value is -0.015 % at the level of 1 % significance.

Conclusions and Policy Implication:

In the current study we focus to explore the impact of ICT investment on the components of human development. ICT investment has categorized into four segments such as communication investment, software investment, hardware investment and services investment, three control variable are added to support the model. Human development index (HDI) has divided into three components such as standard of living which is GDP, education index (EI), life expectancy index (LEI). Developing countries are divided into four panels on the basis of income such as Low.IC, LMIC, Up.MIC and High.IC. The analysis has shown that ICT investment has different impact on the components of human development into four panels of the developing countries.

The results of the current study shows that communication investments have highly significant impacts on standard living (GDP) in lower, LMIC and upper middle economies. Software investment is more effective on GDP growth in LMIC and high income countries. Hardware investment is highly significant on GDP in LMIC and Up.MIC. Services investment is highly effective on GDP in upper middle and High.IC. Individual using internet is highly significant on GDP in Up.MIC. Mobile cellular subscribers are significant on GDP across all the panels. Fixed telephone subscribers are highly significant on GDP in lower middle and Up.MIC. The regression result shows that ICT investment has more effective to increase the GDP level of the developing countries. Government should focus on ICT related field to boost up their growth. Investment on communication, software, hardware and services are highly significant on Education Index (EI) in high income countries. The results explore the High.IC have more focused on ICT related investment as compared to lower, LMIC and High.IC. It is suggested that to improve the education index level, Government should focus on ICT related investment in the developing countries. The analysis results regarding ICT related investment on Life Expectancy Index (LEI) explore that it is less effective in all panels of the developing countries. It shows that government has less focused on ICT related investment in the health sectors. To improve the level of life expectancy index, government should increase the ICT related investment in health sectors. It is also found that communication investment, software investment and hardware investment is highly effective on Human Development index (HDI) in lower and LMIC the concluding remarks of the study is that, ICT investment has impact on the components of human development including HDI in the four panel of developing countries but the significance level is different. Government of the developing countries must be focused to increase the investment on ICT to improve the GDP, EI, LEI and HDI.

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Appendix

List of Countries

Low income economies	lower middle income economies	Upper middle income economies	High income economies
Benin	Bangladesh	Albania	Bahrain
Burkina Faso	Cambodia	Algeria	Brunei Darussalam
Ethiopia	Cameroon	Argentina	Chile
Gambia, The	Côte d'Ivoire	Armenia	Croatia
Guinea	Egypt, Arab Rep.	Belarus	Hungary
Madagascar	El Salvador	Botswana	Oman
Malawi	Ghana	Brazil	Panama
Mali	Honduras	Bulgaria	Poland
Mozambique	India	China	Saudi Arabia
Niger	Indonesia	Colombia	Uruguay
Tanzania	Kenya	Costa Rica	
Togo	Moldova	Ecuador	
Uganda	Mongolia	Kazakhstan	
Yemen, Rep.	Morocco	Mauritius	
	Nicaragua	Mexico	
	Nigeria	Paraguay	
	Pakistan	Peru	
	Philippines	Romania	
	Tunisia	Russian Federation	
	Ukraine	South Africa	
		Sri Lanka	
		Thailand	
		Venezuela, RB	