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RESEARCH ARTICLE

Determinants of information and communication technology (ICT) adoption in developing countries

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Abstract

Background/Objective: The adoption of Information and communication technology (ICT) in developing countries is increasing during last two decades. This study explores the determinants of ICT adoption in 67 selected developing countries. **Methods/Statistical analysis:** Panel data was collected from World Bank and International telecommunication websites for the period of 2000 to 2018. This study explores the impact of access to electricity, ICT good imports, financial development index, GDP per capita, urban population, control of corruption and government effectiveness on ICT adoption. Selected developing countries are divided into four panels such as low income, lower middle, upper middle and high income countries. Pesaran CSD, Friedman CSD and Frees CSD tests are used to check the presence of cross-sectional dependency in the panel data. The results confirmed the presence of cross-sectional dependency in the variables and hence CIPS second generation unit root test is used for stationarity. Kao test is used to check the long run cointegration among the variables. FMOLS is used for regression analysis. **Findings:** The regression results show the mixed findings in different panels. The results indicate that access to electricity is an important determinant of ICT adoption in low and lower middle income developing countries. ICT imports and Government effectiveness are among the significant determinants of ICT adoption in low, upper middle and high income developing countries. GDP per capita is an important variable for each panel. Urban population is found to enhance ICT adoption in lower middle and high income developing countries. It is recommended that Government should focus on these important determinants to increase the ICT adoption in selected developing countries. **Novelty/Application:** ICT development index is used as a dependent variable instead of components of ICT such as internet, mobile phone and computer penetration. New econometrics techniques and variables are used in analysis.

Keywords: ICT adoption; developing countries; influencing factors; hardware; software; panel data

1 Introduction

In the modern era, information and communication technology (ICT) has a significant contribution in all over the world in productivity, growth and efficiency. ICT is the combination of hardware, software, telecommunication and information techniques that are used to store and transform information [1]. It has transferred modern technology in all developing sectors. ICT includes variety of technologies such as computers, broadcasting networks, multimedia, microprocessors, telecommunication & information processing, ICTs related modern technologies services and operation at both organizational and individual levels. It has brought revolutionary changes in traditional economies [2]. ICTs play incredible role in both public and private sectors in the establishment of an electronic society. Mobile communication technology has inspired the growth of communications in the world [3]. ICT is the essential engine of growth and plays an important role in the rapid growth of developing economies. It is argued that ICT has positive spillover impact on many dimensions of social life such as, it enhances learning, improves health care, empowers women, sustains good governance and improves knowledge [4]. ICT produces informative and knowledge based community. It promotes institutional changes in the countries like United States and Finland [5].

Developing countries are facing the problem of technological and innovation capabilities [6]. The diffusion of new technologies in different economies is an intense activity. The penetration of technology has become desirable on national and international level as it may enhance the technical knowledge through improving communication, improves political engagement and also changes the traditional method of productivity in developing countries. ICT adoption has positive impacts on different sectors of developing countries in Middle East, North Africa and the Sub-Saharan Africa region [7]. ICT adoption has also increased the efficiency of resource allocation, reduced communication and production costs and also enhances the investment [8].

The adoption and use of ICT depends on many factors such as performance expectancy, effort expectancy, social influence and facilitating conditions [7]. The determinants of ICT adoption are mainly comprises access to electricity, urban population, infrastructure, FDI, GDP per capital, ICT related good imports and some world governance indicator such as control of corruption & government effectiveness [9]. The adoption level of ICT in a country is measured by many indicators such as mobile cellular subscriptions, number of fixed telephone, Internet users, and broadband subscriptions [8].

The process of new technological adoption is very complex because many qualitative and quantitative factors are involved in adoption process. The adoption has three stages such as initiation, adoption and implementation. The first stage deals with assessing the innovation. In 2nd stage decision is taken to adopt new innovation. The last stage is used to check the effect of innovation. ICT adoption is the use of ICTs tools by using internet [1]. Many researchers claim that adoption of ICT is determined on the base of economic condition of that country. High-income countries adopt faster than low income economies. On the other hand, it is also argue that ICT adoption rapidly grows across the countries apart from level of economic development but the process of adoption and implementation of new technologies is determined by social, political and economic related factors [10].

ICT adoption in any country occurs when Government invests in knowledge technology in order to support the business activities regarding ICT and people start to use it [11]. Adoption of ICT is influenced by many factors. It is classified as; Economic, environmental, legal, Social and cognitive factors. It has experienced that ICT adoption is indigenous technological development in countries [12].

ICT adoption has impact on economy of the world, particularly influence on the economic development, environment, employment, human development and national competitiveness [13]. To produce technological innovations, the adoption of ICT is very important factor to create difference between economies of the world on the basis of socio-economic development. ICT investment has increased in the world at a surprising rate. Expenditures of ICT are mainly driven from five sectors such as: information, manufacturing, finance, social and technical services. These five sectors account for 74 percent of all ICT spending in world and also large percentage of expenditures in ICT sector [12].

ICT adoption is the main indicator of a country's economic achievements. In this perspective, developed countries adopt more rapidly and use new technologies if compared economically to developing countries. Moreover, it is argued that ICT adopted speedily in the World in spite of the level of economic development. On the other hand, adoption level of ICT and execution of new technology is determined by economical, environmental and social related factors [10].

In the modern era, ICT is penetrated in all human fields in the world at record rate. ICT is contributed in all sphere of development such as economic, social and human development in developing countries. Globally, through ICT adoption, developing countries established well-developed communication system and infrastructure and also enhance the capacity which is used in policy implementation and regulation [14]. The declines in the prices of ICT sectors increase ICT adoption in developing countries [15].

Adoption level of ICT, ICT investment and its Impact on development is highly different in developing countries as compared to high income economies due to many reasons. Developing economies have many deficiencies as limited financial resources, unskilled human capital, lack of skills knowledge & computer literacy rate and low knowledge about the benefits of ICT [16]. ICT sector contributed in economic growth by producing more goods and services [17].

ICT adoption factors have been classified into the following categories: economic factors, social factors, legal factors, environmental factors and cognitive factors. These factors have been furthers classified. Economic factors comprises income, cost, financial, trade and wealth related factors [18]. Social factors included to literacy rate, level of access to the new technology, population rate and gender ratio [19]. Legal factors included rules & laws, courts cases and regulation factors. Environmental factors comprise family, religion and life style of people. Cognitive factors included innovation and sharing of ideas among the nations [20].

The current study is organized into six sections as follows: First section describes the brief introduction. The next section, briefly explores the review of literature which indicate the determinant if ICT adoption in different economies. Section 3 shows the descriptive analysis of each panel. In the section 4 revealed the econometric methods which are used in the empirical investigation. Section 5 explains the results of CSD, unit root test, coinegration and regression analysis. The last section briefly discusses the conclusion and policy recommendations from

the empirical findings.

1.1 Importance/Novelty

Many previous studies used the components of ICT like internet, mobile phones and computer penetration as a dependent variable [9,21,22] and [10] but in the current study ICT development Index is used as a dependent variable. Further, developing countries are divided into four groups on the basis of income level. In ICT adoption, Friedman's CSD, Pesaran's CSD and Frees's CSD tests are used to check the cross sectional dependency among the variable and CIPS second generation unit root test is used to check the stationarity of the data and Kao test is used to check the cointegration. Few studies involved econometric techniques. The impact of new economic, social, geographic and government factors such as foreign direct investment, government effectiveness and control of corruption are considered in ICT adoption in the developing economies.

2 Review of Literature

ICT technologies involved sophisticated and modern infrastructure. The adoption of ICT was the path of development which carries to the less greenhouse gas emissions and against the environment degradation [23]. ICT adoption level is increasing in the world and it offers unique opportunities for information systems (IS). It provides a new field for the researcher. ICT adoption depends on economic, social, political and other factors. ICT adoption has positive impact on individual, organizational, industry and economic growth [12]. ICT adoption produces technological innovations and have potential of social welfare and economic growth between different countries [24].

It is studied that internet adoption in 45 developing countries depend on price regulation, transparency, government effectiveness and personal computers per capital [25]. Internet penetration rate neither influenced by the level of education, literacy rate nor democratization. It is strongly dependent on GDP per capita and Research & Development expenditures [10]. The study regarding ICTs' penetration across 161 countries during the period of1999 to 2001 shows that mean years of schooling, illiteracy rate, urbanization, electricity consumption and telecommunication market regulations are positively significant with ICT penetration rates. Income and human capital are positively significant in ICT adoption in both developed and developing countries [26]. The study of ICT adoption in developing economies over the period of 2000-2012 shows that ICT diffusion is determined by urbanization, per capita income, telecommunication market, population density. These factors are significantly effective on ICT diffusion across the developing countries while level of education and prices of telecommunication services are insignificant [27].

ICT adoption is determined by social, economic and cognitive factors. In these factors government effectiveness, human capita, international trade, and adoption of predecessor technologies are positively significant to the ICT adoption rate [28]. Internet penetration rate positively dependent on urban population, education level, per capita income and quality of government institutions [29]. Internet adoption rate is highly significant with urbanization and educational level [30]. ICT adoption rate is low in developing countries than developed countries. The reason behind is that literacy rate in developing economies is less as compared to developed economies. People in the remote areas in developing economies have very limited knowledge about ICTs related technologies [31]. ICT adoption in developing countries is highly dependent on literacy rate. ICT adoption rate is low in African countries due low literacy rate. It is observed that low literacy rate is the main hurdle in ICT adoption in developing economies [32]. Good governance have positively significant to the ICT adoption and its utilization [33]. The level of democracy is significant to internet penetration rate in democratic economies [34].

3 Theoretical framework, model specification, and data

3.1 Theoretical framework and model specification

McKenney & McFarlan in 1982 considered that, identification and investment are the first step of adoption of ICT in any organization [35]. Cooper & Zmud (1990) considered that adoption of new technology as a part of their framework on ICT implementation. They used adoption Model which comprises five stages, such as initiation, adoption, acceptance, routinization and infusion [36]. Umanath & Campbell in 1994 introduced a new Model for differential adoption of information system in multinational organization. Investment is very important in adoption decision of ICT adoption. Investment regarding ICT is considered as investment in software, hardware and personnel [37]. According to Shore (1998) ICT adoption is dependent on economic and environmental characteristics like culture, laws, ICT infrastructure and availability of ICT related skilled persons [38]. Most of the previous studies on ICT adoption have been conducted in developed economies like USA and Europe. The current study focus on ICT adoption in developing economies because there is great difference in ICT adoption in developed countries as compared to developing countries. 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. In developed countries saturation rates are being reached while in developing countries growth is still expected.

The main objective of the current study is to explore the determinants of ICT adoption in developing countries. It was found that GDP per capita, Foreign Direct Investment (FDI), access to electricity, ICT good imports, urban population, Control of Corruption and Government effectiveness are the main factors of ICT adoption in developing countries [21,25,27–29]. ICT Development Index is taken as a dependent variable while access to electricity, GDP per capita, FDI, ICT good imports, Urban population, control of corruption and Government effectiveness are taken as explanatory variable. The relationship between the dependent and explanatory variables is described by using the following empirical

equation:

$$ICTDI_{it} = f(ATE_{it}, GDP_{it}, FDI_{it}, ICTGI_{it}, UP_{it}, CoC_{it}, GE_{it})$$

Whereas ICTDI is expressed as ICT development Index (0-100), ATE indicates access to electricity (% of population), GDP shows GDP per capita (current US $), FDI shows foreign direct investment (% of GDP), ICTGI shows ICT good imports (% of total imports), UP shows urban population, CoC shows Control of Corruption (estimate of governance range from -2.5 to 2.5), GE shows Government Effectiveness (estimate of governance range from -2.5 to 2.5), subscript t shows time period from 2000 to 2018 and i denotes cross section.

3.2 Data and descriptive analysis

Panel data of 67selected developing countries for the period of 2000 to 2018 are collected from World Bank and International Telecommunication Union (ITU) websites. The countries were selected on the basis of data availability. Selected developing countries were categories into four panels on the basis of income according to World Bank criteria; such as low income countries, lower middle income countries, upper middle income countries and high income countries. 14 countries were selected from lower income economies, 20 were selected from lower middle income economies, 23 from upper middle income economies and 10 were selected from high income economies. The variables were selected from Economic factors, environmental factors, legal factors and cognitive factors. The selected variables were access to electricity. GDP, FDI, ICT good imports, urban population, control of corruption and government effectiveness while ICT development index is used as dependent variable. The ITU provides complete data regarding telecommunication sectors of selected variables of all selected countries while World Bank provides complete data on economic, social and legal factors. Table 1 shows the descriptive statistics of four panels such as low income countries, lower middle income countries, upper middle income countries and high income countries. The descriptive statistics shows the difference among the four panels.

4 Econometric procedure

The following steps have been selected in econometric procedure: (a) cross section dependence test (b) unit root test analysis (c) cointegration test analysis (d) regression analysis.

Table 1 shows that average share of access to electricity in lower income countries is 25.512%, 74.445 in lower income countries, 94.534 % in upper middle income countries and 98.6% in high income countries.

Table 1. Descriptive statistics

Panel	Mean	Min.	Max.	Std.Dev.
ICT development index				
Low income Countries	1.226	0.132	3.23	0.612
Lower Middle Income Countries	2.258	0.225	6.45	1.350
Upper Middle Income countries	3.423	0.101	7.55	1.842
High Income Countries	4.239	0.321	7.63	2.157
Access to electricity (% of population)				
Low income Countries	25.512	3.653	79.930	16.272
Lower Middle Income Countries	74.445	15.328	100	22.011
Upper Middle Income countries	94.534	24.8	100	12.302
High Income Countries	98.600	81.401	100	3.601
ICT goods imports (% total goods imports)				
Low income Countries	3.592	0.746	9.176	1.655
Lower Middle Income Countries	5.971	1.421	51.476	6.981
Upper Middle Income countries	8.806	0.006	31.819	5.875
High Income Countries	7.450	1.019	26.068	5.786
GDP per capita (current US$)				
Low income Countries	557.337	111.927	1674.003	264.933
Lower Middle Income Countries	1771.646	258.471	4366.076	1051.955
Upper Middle Income countries	5823.994	622.7421	16054.49	3403.778
High Income Countries	14775.22	3624.198	47741.91	8084.746
Foreign direct investment (% of GDP)				
Low income Countries	4.001	-1.811	39.456	5.261
Lower Middle Income Countries	3.379	-37.154	43.912	4.665
Upper Middle Income countries	4.355	-0.750	55.075	5.273
High Income Countries	4.680	-46.123	54.222	7.906
Urban population				

Continued on next page

Table 1 continued

Low income Countries	5683502	630758	22678295	4262680
Lower Middle Income Countries	42937038	1369717	460000000	82316846
Upper Middle Income countries	53285341	506439	824000000	133000000
High Income Countries	7847499	237094	28255384	8505160
Control of corruption: Estimate				
Low income Countries	-0.695	-1.663	0.007	0.281
Lower Middle Income Countries	-0.712	-1.496	0.369	0.359
Upper Middle Income countries	-0.339	-1.467	1.216	0.558
High Income Countries	-0.329	-1.300	1.216	0.517
Government effectiveness: Estimate				
Low income Countries	-0.052	-1.129	1.056	0.472
Lower Middle Income Countries	-0.483	-1.323	0.643	0.374
Upper Middle Income countries	-0.123	-1.581	1.056	0.497
High Income Countries	-0.147	-1.129	0.725	0.411

4.1 Cross section Dependence Test (CD)

To check the presence of cross sectional dependence in panel data, the following three different testing procedures has adopted; (a) cross section dependence (CD) test of pesaran (b) CD test of Friedman (c) Frees test. The null hypothesis that "there is no CD in panel" has used [39].

a) Pesaran's CD test

Pesaran (2004) has proposed the following CD test:

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

Whereas ^ρ_{ij} shows the residual pairwise correlation sample estimate which was estimated by linear regression equation. The null hypotheses of no cross sectional dependence CD→N (0, 1) for N relatively small and T sufficiently large. The null hypothesis should be accepted if the panel data has no cross sectional dependency. [40].

b) Friedman's test

Friedman (1937) suggested a nonparametric test which is based on Spearman's rank correlation coefficient. Its correlation coefficient is computed the basis of ranking. { r_i,1, . . . , r_i,T} to be the ranks of {u_i,1…..u_i,T } and its average rank is (T + 1/2) [41].

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

c) Frees Test

Frees (1995) proposed CSD test to check the cross sectional dependency in the data. His statistics is based on the following equations;

$$R^2_{ave} = \frac{2}{N(N-1)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\widehat{r}^2_{ij} \tag{3}$$

$$FRE = N\left\{R^2_{ave} - (T-1)^{-1}\right\} \xrightarrow{d} Q = a(T)\left\{x^2_{1,T-1} - (T-1)\right\} + b(T)\left\{x^2_{2,T(T-3)/2} - T(T-3)/2\right\} \tag{4}$$

where $x^2_{1,\,T-1}$, and $x^2_{2,\,T(T-3)/2}$ are independently χ^2 random variables with T − 1 and T (T − 3) /2 degrees of freedom, respectively, $a(T) = 4(T+2)/\left\{5(T-1)^2(T+1)\right\}$ and $b(T) = 2(5T+6)/\{5T(T-1)(T+1\}$. Thus the null hypothesis is rejected if $R^2_{\text{ave}} > (T-1)^{-1} + Q_a/N$, where Q_q is the appropriate quantile of the Q distribution [42].

4.2 Panel unit root tests

Two types of unit root test have developed in panel; (a) first generation unit root test (b) second generation unit root test. The model of a first generation test has analyzed the properties of panel unit root test if the assumption follow that data is independent and identically distributed across the variables [43]. They provide new results on panel unit root test. These tests have some limitations such as it is not applicable if cross-sectional correlation occur in the data. The second limitation of the test is that autoregressive parameters are considered being identical across the panel. The second unit root test rejects the null hypotheses that cross-sectional independence. If cross-sectional dependence occur in panel data then CIPS second generation unit root test was used in the analysis [44]. This test encounters problem of heterogeneity. The main advantage of the test is that small number of unobserved common factors is used cross-sectional dependence model [45].

4.3 Long run cointegration tests

To test the presence of long-run cointegration relationship among the integrated variable, three test such as kao, Pedroni and westerlund are available. Kao is the first author to suggest the test for cointegration in homogeneous panels, The Kao test statistics are calculated by pooling all the residuals of all cross sections in the panel. It is assumed in Kao's test that all the cointegrating vectors in every cross section are identical. Kao test fallow the basic approach of pedroni test. There are main five test under kao cointegaration test namely; (a) Dickey–Fuller, (b) Modified Dickey–Fuller, (c) Augmented Dickey–Fuller, (d) Unadjusted Dickey–Fuller and (e) Unadjusted modified Dickey–Fuller. No cointegration among the variables is null hypothesis of Kao cointegration test. If null hypothesis is rejected then there cointegration exists in panel data. If the probability value of above said five cointegration tes is less than 0.05 value it mean panel data is cointegrated [46].

4.4 Regression analysis

4.4.1 Fully modified ordinary least square (FMOLS)

There are many econometrics techniques are used to investigate the presence of long run relationship among variables. In the current study we used FMOLS econometrics technique to find out relationship between ICT adoption and its determinants in developing countries. Philips and Hansen (1990) was introduced FMOLS method to investigate single cointegration relationship which has combination of I(1). FMOLS method utilizes "Kernal estimators of the Nuisance parameters. It has effect on asymptotic distribution of the OLS estimator [47]. A long run elasticity coefficient is estimated by using FMOLS technique. It has the ability to handle the problem of endogeneity and serial correlation in panel data. This is nonparametric method. It is also reliable for small samples [48].

Pedroni (2004) express mathematical form of FMOLS estimators [49,50] are as under;

$$\beta_{\mathrm{GEM}} = \mathrm{N}^{-1} \sum_{i=1}^{N} \beta_{\mathrm{EMi}}$$

where β_{FMi} is FMOLS estimator applied to ith country and t-statistic is:

$$\mathrm{t}_{\beta \mathrm{GFM}} = \mathrm{N}^{-1/2} \sum_{i-1}^{N} t\beta_{\mathrm{EMi}}$$

5 Result and Discussion

5.1 Cross Sectional Dependence (CD)

[Table 2 and 2.1] 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 CD in the panel data. These three CD test strongly 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 test is less than 0.05. Frees test also reject the null hypothesis of no cross-sectional dependence. Frees test results show that $\mathrm{T} \leq 30$, Frees' test provides the critical values for $\alpha = 0.10$, $\alpha = 0.05$ and $\alpha = 0.01$ from the Q distribution value. Frees statistic is larger than the critical value with at least $\alpha = 0.01$ [39,47].

Table 2. CD test Results

CD Test	Low income Countries		Lower Middle Income Countries		Upper Middle Income countries		High Income Countries	
	Test-stat.	Prob.	Test-stat.	Prob.	Test-stat.	Prob.	Test-stat.	Prob.
Pesaran CD	10.159	0.000	17.823	0.000	27.568	0.000	10.031	0.000
Friedman CD	68.377	0.000	100.759	0.000	159.163	0.000	67.693	0.000

Table 2.1 Frees test Results

CD Test	Low income Countries	Lower Middle Income Countries	Upper Middle Income countries	High Income Countries
	Frees cross sectional independence =1.140	Frees cross sectional independence =2.267	Frees cross sectional independence=3.885	Frees cross sectional independence=1.238
Frees CD test	Critical value	Critical value	Critical value	Critical 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***

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

5.2 Panel unit root test results

Table 3, 3.1 and 3.2 explain unit root analysis results. CIPS test shows mixed results at level form by using only intercept and Intercept & trend but all variable are stationary at first difference. [Table 3] shows CIPS unit root test result at level form by using only intercept. Mostly variables are stationary at level form in four panels. Urban population in low income countries, GDP per capita in lower middle, upper middle & high income countries, Government effect in lower middle income countries, control of corruption in upper middle & high income countries and access to electricity in upper middle income countries are non stationary at level form by using only intercept. Table 3.1 shows that control of corruption is become stationary at level form by using intercept and trend. Table 3.2 reveals that all variable are stationary at first difference by using only intercept. In the presence of CD, we used kao test to check the cointegration among the variable in long run (45).

Table 3. CIPS unit root test: Only intercept (at level)

Variables		Low income Countries	Lower Middle Income Countries	Upper Middle Income countries	High Income Countries
		CIPS	CIPS	CIPS	CIPS
ICT DI		-3.348[a]	-2.893[a]	-2.489[a]	-2.772[a]
ATE		-2.226[b]	-3.570[a]	-1.693	-2.389[b]
FDI		-2.800[a]	-2.397[b]	-2.980[a]	-2.916[a]
ICTGI		-2.992[a]	-2.636[a]	-2.842[a]	-3.535[a]
CoC		-2.483[a]	-2.250[b]	-1.508	-1.743
GE		-2.584[a]	-1.972	-2.395[a]	-2.657[a]
GDPPC		-2.727[a]	-1.331	-1.410	-1.740
UP		-0.728	-2.573[a]	-3.095[a]	-2.850[a]
	1%	-2.47	-2.40	-2.32	-2.60
Critical Values	5%	-2.26	-2.21	-2.15	-2.34
	10%	-2.14	-2.10	-2.07	-2.21

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

Tabel 3.1: CIPS unit root test: Intercept & Trend (at level)

Variable		Low income Countries	Lower Middle Income Countries	Upper Middle Income countries	High Income Countries
		CIPS	CIPS	CIPS	CIPS
ICT DI		-3.541a	-3.165a	-2.849a	-4.247a
ATE		-3.641a	-4.193a	-2.053	-2.643
FDI		-3.069a	-2.462	-3.465a	-2.742c
ICTGI		-3.767a	-2.990a	-3.444a	-3.978a
CoC		-2.770c	-2.730b	-2.636c	-2.984b
GE		-2.991b	-2.337	-2.645c	-3.158a
GDPPC		-2.783b	-2.127	-2.091	-1.958
UP		-1.634	-1.446	-2.104	-2.816c
	1%	-3.01	-2.92	-2.83	-3.15
Critical value	5%	-2.78	-2.73	-2.67	-2.88
	10%	-2.67	-2.63	-2.58	-2.74

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

Tabel 3.2 only intercept (at first Difference):

Variable	Low income Countries	Lower Middle Income Countries	Upper Middle Income countries	High Income Countries
	CIPS	CIPS	CIPS	CIPS
ICT DI	-5.776	-4.913	-4.800	-5.102
ATE	-5.232	-5.672	-2.549a	-3.670
FDI	-4.617	-4.079	-4.871	-4.405
ICTGI	-5.419	-4.521	-4.783	-5.274
CoC	-4.810	-4.506	-3.883	-4.306

Continued on next page

Table 5 continued

GE		-4.422	-4.151a	-4.129	-4.735
GDPPC		-4.024	-2.721a	-2.966a	-2.378b
UP		-2.458b	-2.493	-2.654	-2.407
Critical Values	1%	-2.47a	-2.40a	-2.32a	-2.60a
	5%	-2.26b	-2.21b	-2.15b	-2.34b
	10%	-2.14c	-2.10c	-2.07c	-2.21c

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

5.3 Panel cointegration test results

Table 6 explains the results of cointegration. The results show the presence of cointegration in four panels of developing countries. The null hypothesis that no coimtegration was rejected due to significant test statistics. The long run association established among the variables in four panels.

Table 6. Kao Test for Cointegration

Panel	Statistic	P-Value
Low income Countries		
Modified Dicky-Fuller t	-4.665	0.000
Dicky-Fuller t	-6.109	0.000
Augmented Dicky-Fuller t	-0.845	0.198
Unadjusted Modified Dicky-Fuller t	-12.033	0.000
Unadjusted Dicky-Fuller t	-8.515	0.000
Low Middle income Countries		
Modified Dicky-Fuller t	-2.085	0.018
Dicky-Fuller t	-2.206	0.013
Augmented Dicky-Fuller t	-1.258	0.104
Unadjusted Modified Dicky-Fuller t	-4.328	0.000
Unadjusted Dicky-Fuller t	-3.272	0.005
Upper Middle income Countries		
Modified Dicky-Fuller t	-4.495	0.000
Dicky-Fuller t	-4.380	0.000
Augmented Dicky-Fuller t	-2.781	0.002
Unadjusted Modified Dicky-Fuller t	-6.887	0.000
Unadjusted Dicky-Fuller t	-5.250	0.000
High income Countries		
Modified Dicky-Fuller t	-3.746	0.001
Dicky-Fuller t	-3.537	0.002
Augmented Dicky-Fuller t	-2.270	0.011
Unadjusted Modified Dicky-Fuller t	-4.957	0.000
Unadjusted Dicky-Fuller t	-3.922	0.000

5.4 Regression analysis

[Table 7] shows regression analysis results. Regression analysis explore the relationship between ICT adoption and its selected explanatory variable such as access to electricity (ATE), ICT good Imports (ICTGI), foreign direct investment (FDI), GDP per capita (GDPPC), urban population (UP), control of corruption (CoC) and Government effectiveness (GE) in developing countries.

5.4.1 Access to electricity (ATE)

FMOLS results reveal that access to electricity (ATE) is significant and have positive effect on ICT adoption in low income, lower middle income and upper middle income countries but insignificant in high income countries. The regression results show that 1 % increase in ATE 0.3 % increase in the ICT adoption in lower income countries, 0.2 % in lower middle income countries and 0.5 % in upper middle income countries while no effect on high income countries. [Table 1] shows that average share of access to electricity in lower income countries is 25.512%, 74.445 in lower income countries, 94.534 % in upper middle income countries and 98.6% in high income countries. The descriptive analysis shows that access of electricity is low in lower. Lower middle and upper middle income countries as compared to high income countries due to this fact ATE have no impact on ICT adoption in high income countries. The literature reveals that access to electricity has positively significant impact on ICT adoption [21,26].

5.4.2 ICT good imports

ICT good imports are significant in low, upper and high income countries but insignificant in lower middle income countries. The differences in the results show that the situation is different when we categories countries with respect to the income group. The results of current study explain that one unit change in ICT good imports increased 0.049 units ICT adoption in low income, 0.055 units in upper middle income and 0.396 units in high income countries. The descriptive analysis (Table 1) shows that average values of ICT good imports are more in upper middle income (8.806 %) and high income countries (7.450 %) as compared to low income countries (3.594 %). Due to this fact it is highly effective to ICT adoption in high income economies.

5.4.3 Foreign Direct Investment (FDI)

FDI have different results in each panels. FDI is significant in lower middle income countries but have slightly negative impact on ICT adoption. It means that one unit change in FDI decreased 0.03 units in ICT adoption level. FDI is statistically insignificant in low income, upper middle income and high income countries. The results show that FDI have no impact on ICT adoption in selected developing countries. It is demonstrate that FDI has no impact on ICT adoption in developing countries [22]. Table 2 describes that average shares of FDI in lower income, lower middle, upper middle income and high income countries are 4.001% , 3.379 % , 4.355 % and 4.680 % respectively. Foreign direct investment (FDI) is international trade variable. It also contributes in ICT adoption. It has positive but statistically insignificant impact on ICT adoption [5].

5.4.4 GDP per Capita

Analysis of results explore that GDP per capita has strong impact on ICT adoption in selected developing countries. It shows that GDP per capita has statistically significant in four panels and has positive impact on ICT adoption. The results explain that one unit change in GDP per capita increased 0.008 units ICT adoption level in lower income, 0.001units in lower middle, 0.004units in upper middle income and 0.002 units in high income countries. The literature also reveal that GDP per capita was strongly to ICT adoption in different economies [10,27].

5.4.5 Urban population (UP)

The analysis results show that UP has different economy on ICT adoption in selected developing countries. It is strongly significant in lower middle income and high income countries while insignificant in low income and upper middle income countries. UP has positive impact on ICT adoption in lower middle and high income countries. The results explore that one unit change in urban population increased 7.610 units ICT adoption in lower middle and 9.6 units in high income countries. The descriptive analysis [Table 1] shows that there is highly difference in urban population in different economies of developing countries on the basis of income. High income countries have more urban populations as compared to lower income, lower middle income and upper middle income economies. The studies also explore that ICT adoption level is affected by urban population [27,29,30].

5.4.6 Control of corruption (CoC and Government effectiveness (GE)

The analysis results show that control of corruption is insignificant to ICT adoption in four panels of selected developing countries. It means that CoC has no impact on ICT adoption in developing countries. Government effectiveness has mixed results in different panels of developing economies. GE is highly statistically significant in lower income, upper middle income and high income countries while insignificant in lower middle income countries. The results show that one unit change in GE is increased ICT adoption, 0.511 units in low income countries, 2.406 units in upper middle and 4.720 units in high income countries. The results explore that GE is highly effective in upper middle and high income countries & has no effect on lower middle income economies and less effective in low income countries. The previous studies also reveal that Government effectiveness has strongly impact on ICT adoption in different economies [25,28,33].

Table 7. Panel Fully Modified Least Squares (FMOLS):

Variable	Low income Countries		Low Middle income Countries		Upper Middle income Countries		High income Countries	
	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.	Coeff.	Prob.
ATE	0.034[a]	0.000	0.025[a]	0.000	0.050[a]	0.007	0.011	0.901
ICTGI	0.049[b]	0.025	-0.013	0.382	0.055[b]	0.053	0.396[a]	0.004
FDI	0.006	0.206	-0.032[a]	0.003	-0.033	0.066	0.006	0.718
GDPPC	0.008[a]	0.000	0.001[a]	0.000	0.004[a]	0.000	0.002[a]	0.000
UP	1.230	0.547	7.610[b]	0.053	-2.060	0.486	9.600[a]	0.009
CoC	-0.163	0.242	-0.023	0.940	-0.67	0.145	-1.519	0.321
GE	0.511[a]	0.001	-0.476	0.156	2.406[a]	0.000	4.720[a]	0.001

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

6 Conclusions and policy implication

The current research demonstrated that there are long run cointegrations among ICT adoption, access to electricity, GDP per capita, FDI, ICT good imports, urban population, control of corruption, government effectiveness in 67 developing countries. The regression results show that

selected ICT adoption determinants have different results in each panel on the base of income. The access of electricity is more effective in low income and lower middle income countries. The analysis results explore the access to electricity is less in low income (25.512 %) and lower middle income (74.445%) countries. It is guideline for the policy-maker should focus on electricity supply in above said both panels because it has great impact on ICT adoption in lower and lower middle income developing countries. Access to electricity is important factor of ICT adoption. ICT good imports are also an important factor for ICT adoption in selected developing countries. It is more effective in three panels of developing countries, lower income, upper middle and high income countries. The results show that it is important determinant for ICT adoption in developing economies but average ICT good imports ratio is low in lower (4.001 %), upper (4.355%) and high income (4.680%) economies. The Government should increase imports of ICT related goods. FDI is no more effective on ICT adoption in developing countries. GDP per capita is an important determinant of ICT adoption in each panel of selected developing countries. GDP per capita increase one unit it increased 0.008 units in low, 0.001 units in lower middle, 0.004 units in upper middle and 0.002 units in high income countries. Increase in GDP per capita increased ICT adoption in developing countries. Urban population has mixed results in selected developing countries. It is not effective in two panels such as low income and upper middle income countries but it is an important factor in lower middle and high income economies. Urban population is more in high income countries as compared to other panels. Control of corruption is not important factor for ICT adoption in developing countries. Government effectiveness is an important determinant of ICT adoption. Government should make effective rules and regulation which enhance ICT adoption in developing countries. Policy maker should focus on GE determinant and provide guideline to the government which is more effective for ICT adoption in developing countries.

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