Does ICT Participate in Economic Convergence among Asian Countries: Evidence from Dynamic Panel Data Model

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Conventional Convergence models usually oversee the role of information and communications technology (ICT) as a determinant of convergence. This paper introduces ICT as a factor contributing towards economic convergence in Asian countries. In addition to ICT, other factors like demographic traits, level of human development and electricity consumption are used as regressors. System GMM technique is used to estimate convergence regression for selected Asian countries for data of time span 2001-2010. Support for ICT-augmented convergence is found, implying that ICT has the tendency to participate in convergence process. Suitable demographic features, human development and electricity consumption are also found to contribute to economic convergence in the sample countries of Asia. Findings of this paper indicate the need to complement the favorable demographic endowments in Asian economies with economically productive usage of ICT to proceed towards economic convergence in Asian Region.

Keywords: *Convergence Models, Information and Communication Technology (ICT), System Generalized Method of Moments (SYS-GMM), Human Development Index (HDI), Electricity Consumption*

1 Introduction

Importance of information has been pivotal since beginning of human civilization. Since time immemorial the information has been serving as a competitive edge for its possessors [12]. During 20th century, the advent of digital devices has hotfooted the flow of information and ability to process it. This technology is termed as Information and communication technology (ICT). During the last half of 20th century, 'information revolution' was made possible through the 'digital' Information and Communication Technology 'ICT' [12]. The ICT revolution is crucial insofar as it involves technologies geared to the production and dissemination of knowledge and information. These new technologies, that first emerged in the 1950s and then really took off with the advent of the Internet, have breathtaking potential. It is worth noting that the differences between communication technology and information technology have become fuzzy. e.g. mobile phones are principally tools for communication. But with the invention of wireless technology, users can access information via cellular phone. Internet is primarily a tool of information technology, yet many Internet users communicate mutually through their personal computers.

Economic convergence refers to the process by which relatively poorer regions or countries grow faster than their rich counterparts. The convergence hypothesis is advanced by [22] and is documented by [8] and [5]. This paper includes ICT and in economic convergence and calls it ICT-augmented. For the sake of simplicity, the word 'Economic convergence' is interchangeably used as 'convergence'. As documented in empirical literature, conditional beta convergence is a more realistic exercise because it reflects the convergence of countries after controlling for differences in steady states. Absolute sigma (σ) convergence is another form of convergence theory but suffers with lack of empirical evidence. Conditional convergence is simply a confirmation of a result predicted by the neoclassical growth model: those countries with similar steady states exhibit convergence. This does not imply that all countries in the world would converge to the same steady state; rather they would converge to

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their own steady states.

2 Objective

This paper inquires the role of ICT in achieving economic convergence among Asian countries. It is expected due to miraculous ability of ICT to process information and hence become economically meaningful. Classic evidence of this ability is Moore's law that purports an exponentially increasing 'information processing' capability in microelectronics, society and economy. Another instance is Gilder Law that asserts bandwidth of network would triple each year for the span of 25 years. Till date this prediction is almost true. Therefore, it is pertinent to discuss the role of ICT in the convergence hypothesis. This paper empirically examines the role of ICT in economic convergence after including demographic features, level of human development and electricity consumption.

3 Literature Survey

Convergence regression has been estimated with a variety of explanatory variables. [13] incorporates federal transfers in the convergence regression to inquire its role in growth. However results do not imply convergence. In similar veins, [21] attempts to explicate regional output inequality within 13 EU countries, and uses social transfers as an explanatory fiscal variable. Author does find evidence of convergence using the social transfers in reducing output inequality.

The efforts to incorporate ICT as an explanatory variable are rare and a noticeable effort in this regard is in [16]. His exercise of growth empirics on member states of European Union reveals that R&D expenditure initiated from abroad impacts GDP growth positively and in a statistically significant way. To augment the literature for Asian region, this paper quantitatively assesses the role that ICT play in convergence regressions for the sample countries.

Flowchart gives a scheme of theoretical framework in this paper. There is innovation in [4] is the addition of ICT as a factor contributing to economic convergence. Since ICT is empirically evidenced as an agent of economic growth, it can be tested as a factor that enters positively into convergence regression.

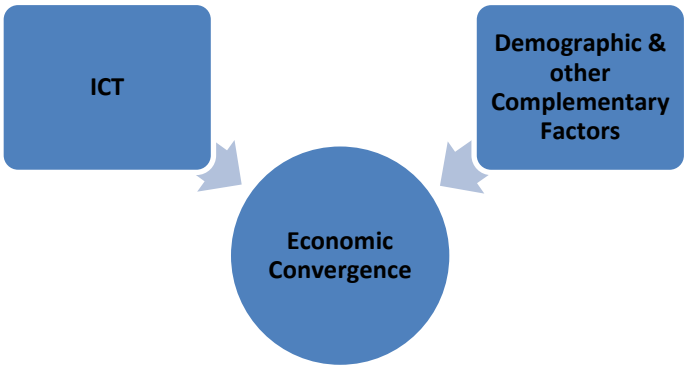

Fig. 1. Converging Radial Diagram for ICT Augmented Convergence Hypothesis
Source: Inspired from Barro and Sala-i-Martin (1992)

4 Estimable Model for ICT Augmented Convergence Hypothesis

This paper reposes on this literature and elaborates existing findings by using a rigorous methodological approach applied at a regional level panel dataset. Foundation for the analysis is provided in [4] in terms of conditional convergence. In this paper, the growth equation in [4] is augmented with ICT. The use of ICT and knowledge related variable(s) is justified for long run steady state growth due to non-decreasing returns. The trait of knowledge of being non rival and hence passing without diminishing its value allows for non-decreasing returns. This paper examines the role of ICT in determining the conditional convergence across selected Asian

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countries which will be tested by estimating the following model:

$$\mathbf{YPC_{i,t} = \varphi\ (YPC_{i,t-1},\ ICTMI_{i,t},\ ICTSERT_{i,t},\ p1564_{i,t},\ URBNP_{i,t},\ TRD_{i,t},\ ELTKW_{i,t},\ YPC_{i,t(0)})} \quad (1.1)$$

$$\mathbf{YPC_{i,t}} = \alpha_{i,t} + \alpha'_{i,t}\ \mathbf{(YPC_{i,t-1})} + \beta_{i,t}\ \mathbf{(ICTMI_{i,t})} + \gamma_{i,t}\ \mathbf{(ICTSERT_{i,t})} + \delta_{i,t}\ \mathbf{(p1564_{i,t})} + \kappa_{i,t}\ \mathbf{(URBNP_{i,t})} + \lambda_{i,t}\ \mathbf{(TRD_{i,t})} + \zeta_{i,t}\ \mathbf{(ELTKW_{i,t})} + \xi_{i,t}\ \mathbf{(YPC_{i,t(0)})} + \eta_i + \varepsilon_{i,t} \quad (1.2)$$

Where, $\mathbf{YPC_{i,t}}$ is income per capita estimated as the ratio of national income and $\mathbf{YPC_{i,t-1}}$ is one year lagged version of income per capita, rendering the model dynamic. **ICTMI** is Information & Communication Technology Maturation Index. For the complementary effects between ICT and tertiary level education, **ICTSERT** as a product of ICT and SERT is included among regressors. SERT 'tertiary school enrolment (% gross)' as a proxy of human capital is used following [5]. In lieu of 'secondary school enrollment' (**SERS**), SERT is chosen because ICT users with higher levels of education are economically more productive. [11] also advocate the role of SERT in improving ICT diffusion in an economy and hence likely to be a reinforcing factor for ICT-productivity nexus. It reveals the interaction effects of ICT and school enrolment rate at tertiary level. To include the complementary effects culminating from demographic features, **p1564** (population with at between 15 and 64 years) and **URBNP** (%age of urban population) are included. Welfare related complementarily is investigated using **HDI** (Human development index) and **ELTKW** is the technology related determinant income growth by using the variable 'electric power consumption in kWh'. $YPC_{i,t(0)}$ is the initial condition of YPC included to test existence of the ICT-augmented conditional convergence. [21] discover 'conditional convergence' to be a robust characteristic of growth regressions, i.e., it holds true for many 'conditioning variables'. Following is the detailed table of data definition and sources:

Table 1. List of Countries, Variables, their Definitions and Data Sources

Sr. No.	Variable & its Notation	Definition	Source
1	Logarithm of GDP per capita, PPP (constant 2005 international $) $\mathbf{YPC_{i,t)}}$	"GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 international dollars."	WDI 2011
2	Labor force, total $\mathbf{L_{i,t}}$	Total labor force comprises people ages 15 and older who meet the International Labor Organization definition of the economically active population: all people who supply labor for the production of goods and services during a specified period. It includes both the employed and the unemployed. While national practices vary in the treatment of such groups as the armed forces and seasonal or part-time workers, in general the labor force includes the armed forces, the unemployed, and first-time job-seekers, but excludes homemakers and other unpaid caregivers and workers in the informal sector.	WDI 2011

3	Human Development Index $\mathbf{HDI_{i,t}}$	$HDI = (Lifex * EDUx * GDPx)^{1/3}$
		Where;
		• Lifex = (Life-20)/(83.166(Japan,2010)-20)
		• $EDUx = (Litx * GERx)^{1/2}$
		  ○ Litx = (Lit-0)/(99(several countries, several years)-0)
		  ○ GERx = (GER-0)/(115.8192(Australia,2002)-0)
		• GDPx = (ln(GDP)-ln(163.28143(Liberia,1995))/(ln(106769.74(UAE,1977))-
			UNDP

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		ln(163.28143(Liberia,1995)).	
4	Urban population **URBNP$_{i,t}$**	"Urban population refers to people living in urban areas as defined by national statistical offices. It is calculated using World Bank population estimates and urban ratios from the United Nations World Urbanization Prospects."	WDI 2011
5	Population ages 15-64 (% of total) **P1564$_{i,t}$**	Population ages 15 to 64 is the percentage of the total population that is in the age group 15 to 64. Population is based on the de facto definition of population.	WDI 2011
6	Fixed telephone lines per 100 inhabitants **FTL$_{i,t}$**	"It refers to the number of fixed telephone lines in a country for each 100 inhabitants." **Calculation:** by dividing the number of fixed telephone lines by the total population and then multiplying by 100.	ITU 2011
7	Mobile cellular telephone subscriptions per 100 inhabitants **MBLC$_{i,t}$**	"It refers to the number of mobile cellular telephone subscriptions in a country for each 100 inhabitants." **Calculation:** by dividing the number of mobile cellular telephone subscriptions by the total population and then multiplying by 100.	ITU 2011
8	Fixed broadband Internet subscribers **FBBS$_{i,t}$**	"It refers to the number of fixed broadband internet subscribers in a country for each 100 inhabitants." **Calculation:** by dividing the number of fixed broadband Internet subscribers by the total population and then multiplying by 100.	ITU 2011
9	Fixed Internet subscribers per 100 inhabitants **FIS$_{i,t}$**	"It refers to the number of fixed internet subscribers in a country for each 100 inhabitants." **Calculation:** by dividing the number of fixed Internet subscribers by the total population and then multiplying by 100.	ITU 2011
10	Internet users per 100 inhabitants **INTU$_{i,t}$**	"It refers to the number of internet users in a country for each 100 inhabitants." **Calculation:** by dividing the number of mobile broadband subscriptions by the total population and then multiplying by 100.	ITU 2011
11	Information & Communication Technology Maturation Index **ICTMI$_{i,t}$**	= (Fixed telephone lines per 100 inhabitants) + 0.2 * (Mobile cellular telephone subscriptions per 100 inhabitants) + 0.2 * (Fixed broadband Internet subscribers) + 0.2 * (Fixed Internet subscribers per 100 inhabitants) + 0.2 * (Internet users per 100 inhabitants)	Own Calculation
12	School enrollment, tertiary (% gross) **SERT$_{i,t}$**	"Gross enrolment ratio is the ratio of total enrolment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level."	WDI 2011
13	ICT goods imports (% total goods imports) **ICTM$_{i,t}$**	Information and communication technology goods imports include telecommunications, audio and video, computer and related equipment; electronic components; and other information and communication technology goods. Software is excluded.	WDI 2011

In order to estimate the described scheme in panel data regressions, it is assumed that a higher level of initial per capita GDP reflects a greater stock of physical capital per capita following [5]. Following [24], it is also assumed that the initial stock of human capital is reflected in the lagged value of per capita output in the short-run. The Solow-Swan model predicts that, for given values of the control variables, an equi-proportionate increase in the initial levels of state variables reduces the growth rate. Thus we can write the model of output per capita growth rate for this panel dataset as:

$$(\mathbf{y}_{i,t} - \mathbf{y}_{i,t-1}) / \mathbf{y}_{i,t-1} \approx \boldsymbol{\alpha}\mathbf{y}_{i,t-1} + \mathbf{X}_{i,t}\,\boldsymbol{\beta} + \boldsymbol{\nu}_i + \boldsymbol{\tau}_t + \boldsymbol{\varepsilon}_{i,t} \quad \text{……………………………………….(1.3)}$$

Where, $y_{i,t}$ is per capita gross domestic income (GDI) in sample country i (i = 1, …, 11) during the period ***'t'*** (t = 2000 ,…, 2010), $y_{i,t-1}$ is the initial per capita GDP in region ***'i'***

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in period ***'t-1'***, '**α<0'** reflecting the convergence speed, $X_{i,t}$, is a row vector of control variables in region ***'i'*** during period ***'t'*** with associated parameters 'β', 'ν_i' is a country specific effect and $\varepsilon_{i,t}$ is the error term. If we assume that:

$$(y_{i,t} - y_{i,t-1}) / y_{i,t-1} \approx \ln(y_{i,t} / y_{i,t-1}) \quad \text{..... (1.4)}$$

we can approximate equation (1.3) as:

$$\ln(y_{i,t} / y_{i,t-1}) = \alpha \ln (y_{i,t-1}) + \ln X_{i,t}\beta + \nu_i + \tau_t + \varepsilon_{i,t} \quad \text{..... (1.5)}$$

Moving $\ln(y_{i,t})$ from right-hand side to left-hand side, we obtain the dynamic panel data model:

$$\ln y_{i,t} = (\alpha+1) \ln (y_{i,t-1}) + \ln X_{i,t}\beta + \nu_i + \tau_t + \varepsilon_{i,t} \quad \text{..... (1.6)}$$

5 Sampling and Estimation Techniques

The dimensions of dataset are 24 countries (Bangladesh, Bru Nei Darul Islam, China, Indonesia, India, Iran, Israel, Jordan, Japan, Kazakstan, Kryzgystan, Cambodia, Korea, Kowait, Lao PDR, Malaysia, Oman, Pakistan, Philippines, Russia, Saudi Arabia, Thailand, Tajikstan and Yemen) and 11 years (2000-2010) which are mostly dictated by the availability of data. Collection of data is done from World Development Indicators (WDI) and International Telecommunication Union (ITU) for selected Asian countries.

Test for potential endogeneity and heteroskedasticity have been applied that reveal that endogeneity and heteroskedasticity both exist via statistical significance of test statistics. More specifically, existence of endogeneity calls for IV estimation and presence of heteroskedasticity necessitates GMM estimator.

Table 2. Durbin-Wu-Hausman Tests For Endogeneity In IV Estimation

Null Hypothesis (H_o): Regressor is Exogenous			
Test	**Notation**	**Statistic**	**p-value**
Wu-Hausman F test	F(1, 206)	42.049	**0.0000**
Durbin-Wu-Hausman χ^2 test	$\chi^2(1)$	44.001	**0.0000**

Table 3. IV-Heteroskedasticity Tests Using Levels Of IVs

Null Hypothesis (H_o): Disturbance is Homoskedastic			
Test	**$\chi^2(6)$**	**p-values**	
Pagan-Hall General Test Statistic		11.542	**0.1728**
Pagan-Hall Test w/assumed Normality		15.110	**0.0570**
White/Koenker nR_c^2 Test Statistic		21.155	**0.0067**
Breusch-Pagan/Godfrey/Cook-Weisberg		30.214	**0.0002**

Panel data models with small samples produce biased coefficient estimates using ordinary least squares 'OLS', fixed effects 'FE' and random effects 'RE' [3]. Such bias is tackled with using estimators based on the General Method of Moments 'GMM', which are consistent for 'n → ∞' with fixed ***'t'***. System Generalized Method of Moments 'SYS-GMM' is employed for the panel data analysis. GMM estimation technique is attributed to [2] which is ameliorated as 'SYS-GMM' by [9]. SYS-GMM is a better estimation technique since **i)** differencing eliminates the unobservable country-specific effects; **ii)** instrumental-variable 'IV' approach deals with the endogeneity of explanatory variables; **iii)** 1st-differenced estimator is combined with the estimator in levels to form a more efficient 'system estimator'.

$$Z_{i,t} = \beta X_{i,t} + \nu_i + \eta_{i,t} \quad i = 1,...,N;\ t = 1,...,T \quad (1.7)$$

Where **Z** is the given dependent variable, **X** is a row vector of control variables. ν_i represents the unobserved country level effect and $\eta_{i,t}$ is the error term, assumption that ν_i and $\eta_{i,t}$ are independent for each ***'i'*** over all ***'t'*** and there is no autocorrelation in $\eta_{i,t}$. Using the methodology of SYS-GMM, this section estimates the effect of ICT on economic convergence across the sample countries.

[19] has suggested a method to inquire the existence of convergence using system GMM (SGMM). This assumption necessitates a steady state in the logic that deviations from long run values are not systematically associated to the fixed effects. Stating in terms of coefficients, convergence occurs if the coefficient of the lagged dependent variable in

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the model is less than 1 in absolute terms. [20] also suggests that if the coefficient of the lagged dependent variable exceeds 1, SGMM becomes void. For convergence process another condition is laid in [19] that "deviations from the steady state level must not be correlated with the fixed effects ($\hat{u}_{i,t}$)". Such can be achieved by incorporating the initial condition of the dependent variable in the regression equation.

Post estimation tests include Hansen test of over-identifying restrictions that is a joint test of model specification and appropriateness of the instruments. SYS-GMM uses more instruments than DIFF-GMM causing the Sargan test to be weak. However, in this study, the Hansen (Robust Sargan) test is used which overcomes this weakness of Sargan test. Moreover, the rule of thumb that number of instruments ≤ number of countries is also considered for this statistical concern [18]. Hence our choice of SYS-GMM survives this statistical concern. This test statistics indicates that the model is well specified and the instrument vector is appropriate. Moreover, [2] test, applied to differenced residuals, for the first order AR(1) and second order AR(2) serial correlations are also estimable. AR(1) is expected to reject null hypothesis of no autocorrelation since both of the following difference equations have $\boldsymbol{\varepsilon_{i,t-1}}$:

$$\boldsymbol{\Delta\varepsilon_{i,t} = \varepsilon_{i,t} - \varepsilon_{i,t-1}} \quad (1.8)$$

$$\boldsymbol{\Delta\varepsilon_{i,t-1} = \varepsilon_{i,t-1} - \varepsilon_{i,t-2}} \quad (1.9)$$

Test for AR(2) is more important since it inquires the presence of autocorrelation in levels and should be insignificant.

Table 4. SYSTEM GMM Estimates (Role of Demographic Complementary Factors and ICT in Convergence)

Dependent Variable: Gross National Income ($YPC_{i,t}$)				
	Coefficients	**Standard Errors**	**t-statistics**	**p-values**
$YPC_{i,t-1}$	**0.9617**	0.0487	19.75	0.000
$ICTMI_{i,t}$	**0.0119**	0.0052	2.29	0.023
$ICTSERT_{i,t}$	**0.0028**	0.0010	2.84	0.005
$P1564_{i,t}$	**0.1042**	0.0731	1.43	0.156
$URBNP_{i,t}$	**0.0223**	0.0063	3.51	0.001
$TRD_{i,t}$	**-0.0558**	0.0301	-1.85	0.065
$ELTKW_{i,t}$	**1.2082**	0.1600	7.55	0.000
$YPC_{i,t(0)}$	**-0.0584**	0.0240	-2.44	0.016
C	**-0.1483**	0.3543	-0.42	0.676
Time Dummies				
yrtd_02	0.0176	0.0167	1.06	0.291
yrtd_03	0.0246	0.0153	1.61	0.110
yrtd_04	0.0265	0.0133	2.00	0.047
yrtd_05	0.0213	0.0117	1.83	0.069
yrtd_06	0.0196	0.0111	1.77	0.079
yrtd_07	0.0200	0.0109	1.84	0.067
yrtd_08	0.0009	0.0114	0.08	0.939
yrtd_09	-0.0297	0.0160	-1.86	0.065
Other Tests and Statistics				
Obs. = 216	**Countries** = 24	**Instruments** = 30	**F(15, 23)** = 7162 **[p** = 0.000]	
p-value: Hansen J-Test = 0.222		**M_1:** p = 0.208 & **M_2:** p = 0.301		
Difference in Hansen tests / C-tests: [p = 0.244, p = 0.308, p = 0.137 & p = 0.433]				
Source: Author's calculations using **Stata (Special Edition) 12.0** user defined command **xtabond2**				

Notes: Following [19], model is estimated by two steps SGMM with argument **small**.

In this estimation, ICT goods imports (% total goods imports) $ICTM_{i,t}$ is used as in additional instrumental variable following [18]. It is selected as an additional since it is expected to have no direct and significant relation with national income but is highly suspected to directly increase ICTMI. It is because in most of the sample countries, the

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ICTMI components (FBBS, FIS, FTL, INTU and MBLC) are not domestically produced rather imported. Therefore, use of ICTM as an additional instrument is justified. Consequently, due to lack of association between YPC and ICTM and strong association between ICTM and ICTMI, ICTM is used as an 'external instrument' as suggested in [20].

Explanatory Notes:
i) The standard errors are given in parentheses. **ii)** t-statistics are based on standard errors. **iii)** Number of instruments < number of observations as advocated in [19] & [20] & p-value of Hansen J-Test is considerably higher than conventional levels of 0.05 and 0.01 as suggested in [20]. **iv)** Difference-in-Hansen tests or C-tests are applied to check the validity of subsets of instruments for:

- **i.** the instruments of the level equations (exogenous variables & time dummies excluded);
- **ii.** exogenous variables & the time dummies, and;
- **iii.** moment conditions produced by the differences equations (exogenous variables & time dummies excluded).

There is not enough evidence to reject the null hypotheses set in these four tests of difference-in-Hansen/C-tests.

6 Interpretation

The estimated coefficient on the lagged dependent variable is 0.9617 which is less than 1, which means that the steady-state assumption holds. Moreover, the initial condition variable comes with a negative sign (-0.1483) and implies higher growth in response to lower starting YPC when other regressors are kept constant. Such concurs with the findings in [6] and [17].

Information and communication technology (ICTMI) is statistically significant and has a positive influence on YPC (national income) as depicted by its positive sign of regression coefficient (0.119% increase in national income due to 10% increase in ICTMI). ICTSERT (ICT×SERT) is also used in the regression which captures the interaction of ICT and school enrollment rate at tertiary level. This coefficient is statistically significant and has positive influence on national income (0.028% increase in national income due to 10% increase in ICTSERT). This implies that ICT has complementarily with tertiary level of education. In simpler terms, highly educated users (labor) of ICT are economically more productive labor. Similar results are also expected from ICTSERS (ICT×SERS) an interaction of ICT and school enrollment rate at secondary level. But due to relatively lower level of education, the influence on national income is likely to be lower. Moreover, a smaller portion of population having secondary education is likely to be ICT users, while a bigger portion of population having tertiary education is expected to be ICT users. Therefore, the proxy ICTSERS is not empirically tested in this research. [1] for some Asian countries, highlight the weaknesses of tertiary education system that is dominated by client-oriented private sector institutions.

The proxy for economically active youth, population aged between 15-64 years is also included. Though age group up to 64 years is not considered young, but lack of data on below 50 years of age of population is not available, so this proxy is dictated by data availability. The meaning of young population here is in terms of their contemporariness to ICT and physical and mental fitness to adopt and use ICT. It shows a positive relationship with national income (0.1042% increase in national income due to 1% increase in p1564). It is justified since young labor force is more ICT-savvy. 'ICT-savvy' means proficient user of information and communication technology. ICT revolution is not more than two or three decades older, accordingly the younger population has undergone proper training of ICT under academic programs. United Nations (UN), World Summit on the Information Society (WSIS) and World Programme of Action for Youth (WPAY) also confirm the high potential of youth in learning the use and development of ICT applications.

Another segment of population that is hypothesized to be relatively more productive is

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the urban population. Population in urban areas gets better education and job opportunities due to urbanization economies. Urbanization economies contain benefits like proximity of markets, skilled and more educated labor, financial services, better information and communication facilities and knowledge spillovers. Considering these facts, this demo-tech income regression includes urban population (URBNP) along with ICT as demographic factor. This regressor is showing positive influence on national income and supporting the argument of urbanization economies (0.223% increase in national income due to 10% increase in URBNP). It is statistical significant. In an economic jargon, this coefficient indicates towards 'ICT-augmented agglomeration economies' in large urban areas. This term is devised from the standard term of agglomeration economies.

Trade openness **TRD** turns out to be positive contributor to national income (-0.558% increase in national income due to 10% decrease in TRD). Its negative role can be attributed unfavorable terms of trade for developing countries, majority of which can be seen in our sample.

Electricity consumption in this regression justifies its inclusion via positive sign of its coefficient and significance at 1%. Moreover, in terms of magnitude, its coefficient is the highest (1.2082% increase in national income due to 1% increase in ELTKW). Because the role of electricity consumption is not limited only to complementing the ICT. Rather electricity consumption complements other non-ICT sectors as well and contributes to economic growth via other channels. The role of electricity for ICT is not only in complementary rather it serves as a pre-requisite for ICT to function. Consequently, it is safely stated that electricity consumption has strong complementarily with ICT.

Overall significance of the model is acceptable (at 1%, 5% and 10% levels of significance) as revealed by F-test of joint significance. The condition that number of observations is greater than number of instruments holds in this case i.e. (216 > 30). Hansen test of correct specification and over-identifying restrictions has a p-value of greater than 0.05. i.e. (p-value = 0.222 > 0.05) implying that all over-identified instruments are exogenous. The Arellano & Bond test for first order 'M_1' and second order 'M_2' correlation i.e. AR(1) and AR(2) show p-value of greater than 0.000. i.e. $(M_1)_{p\text{-value}} = 0.208 > 0.05$ and $(M_2)_{p\text{-value}} = 0.301 > 0.05$. Hence there is no second order serial correlation in residuals.

C-test ([7]; [19]) for the validity of subsets of instruments for level and difference equations are also satisfactory. These tests are four in number and have same criteria, i.e. the p-value should be greater than 0.05:

(C-test)$_{Ho}$: GMM-differenced instruments are exogenous = 0.244 > 0.05

(C-test)$_{Ho}$: system GMM instruments are exogenous & they increase Hansen J-test = 0.308 > 0.05

(C-test)$_{Ho}$: GMM instruments excluding IV-instruments are exogenous = 0.137 > 0.05

(C-test)$_{Ho}$: Standard IV-instruments are exogenous & they increase Hansen J-test = 0.433 > 0.05

There is not enough evidence to reject the null hypotheses set in these four tests of difference-in-Hansen/C-tests.

7 Conclusion

Based on empirical results in this paper the role of ICT in achieving convergence which is found to be supportive. Though the magnitude of relationship is not large yet it is substantial form the point of view of UDCs. Since in UDCs ICT is adopted and not produced domestically, its contribution is expected to be low as compared to that in ICT producing countries (some DCs). The contribution is economically meaningful as well. The richest ICT related regional databases are found in case of OECD countries for instance 'ICT database and Eurostat'. In UDCs, access to ICT is also low as compared to that in that in DCs but an optimist fact is the presence of youth and other favorable demographic features. Some of the problems of scientific research in developing countries, such as creating an increased pool of trained people, providing more resources and strengthening the whole national infrastructure, can only be solved through time. Policy

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makers should focus more on designing the policy in considering ICT as a phenomenon, deeply embedded into every sector of the economy.

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