Information Communication Technology (ICT), Human Capital and Economic Growth: A case study of selected developing countries.

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LIST OF ACRONYM

ICT	Information Communication Technology
HC	Human Capital
GROWTH	Economic Growth
ICTHC	Interaction term of information communication technology and economic growth
GOV	Government size
INF	Inflation
INV	Investment
OPEN	Trade openness
PCA	Principal Component Analysis
WDI	World Develop Index
PWT	Penn Word Table
Yo	initial value of real per capita GDP

ABSTRACT

This study examines the linkage between information communication technology and economic growth through the channel of human capital. We use panel data set of 44 countries for the period of 2000- 2014.To capture this indirect relationship we use moderated mediation method. It explores whether the channel of human capital neutralizes, increases or reduces the effect of ICT on Growth. To empirically investigate our econometric model we use Seemingly Unrelated Regression (SUR) method as suggested by Biorn (2004). Findings of our study are as follows: First, information communication technology has significant negative impact on growth. Second, the effect of ICT on economic growth through the channel of human capital becomes positive and significant. So, we conclude that the impact of ICT on Growth is negative directly whereas it is positive indirectly.

DECLARATION

I hereby declare that this thesis, neither as a whole nor as a part, thereof, has been copied out from any source. It is further declare that I have carried out the research by myself and have completed this thesis on the basis of my personal efforts under the guidance and help of my supervisor. If any part of this thesis is proven to be copied out or earlier submitted. I shall stand by the consequences. No portion of work presented in this thesis has been submitted in support of any application for any other degree or qualification in International Islamic University or any other university or institute of learning.

Anam Majeed

DEDICATION

Dedicated to my loving mother, family and all teachers

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My first words of thanks to the one who taught words to Adam, the creator of mankind, who blessed man with knowledge. After that my humblest thanks to our beloved prophet (PBUH), who is the fountain of knowledge for whole mankind.

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Chapter 1

Introduction

Nations' wealth and growth is ultimately driven by productivity; hence if workers are productive they will earn higher wages and in return their standard of living will be improved. Therefore, studying the driving force behind productivity and growth is very important (Kretschmer, 2012). In the modern world, Information Communication Technology (ICT) is becoming an important factor of economic growth (Van, 2003). Similarly, Jorgenson et al (2005) document that ICT is having a strong impact on different countries in the field of communication, working and learning; even then there is a need to describe "how ICT affects economic growth?". Further, Thioune (2003) examines that countries are growing and many developed countries of the World are subject to different changes in different fields of life such as economics, education and health etc and the reason of change is ICT.

There is no official definition of ICT; different authors explain it differently, such as Anayakoha (1991) defines it as "The use of man-made tools for collection, generation, communication, recording, remanagement and exploitation of information. It includes those applications and commodities, by which information is transferred, recorded, edited, stored, manipulated or disseminated". Similarly, Hawkridge (1983) argues that ICT is a revolution that is transforming our social and economic life.

Schware (2006) documents that according to World Bank's (2005) "E-development report", developed middle income and developing countries can extract benefits from having an effective ICT sector. Moreover, UNDP (2001) concludes that technology is not only the result of growth but it also helps in boosting up the economic growth. Further, in June 1996, UNCSTD (United Nations commission on science and technology development) in

collaboration with IDRC (international development research center) proposed five development indicators that help in improving the quality of life are given as follows: education, health, income, governance and technology (Crede and Mansell, 1998). A study conducted by Manyika (2011) shows that if internet consumption and expenditures belong to a particular sector, it contributes more to GDP than any other sector; therefore, ICT is an important factor of economic growth.

ICT and human capital are complementary factors that contribute positively to economic growth as shown by Brynjolfsson (2000), Bertschek and Kaiser (2004). Bresnahan (2002) test the hypothesis of complementary between organizational computing and skill in firms, he concluded that ICT, human capital and organization produce distinctive positive and significant effects on labour productivity. However evidence on complementary is wide spread. Different studies are conducted to check the impact of ICT indicators on economic growth, for example Czernich et al (2009) finds a positive relationship between ICT (broadband infrastructure) and growth. ICT affects economic growth directly by introducing new technologies such as broadband, new mobiles etc and indirectly by affecting human capital or labor productivity.

In this study, we construct a composite measure of ICT indicators for selected developing countries. Then we examine the effect of ICT on growth through the channel of human capital. Further, we also explore the conditional effects of ICT on growth for different levels of human capital. These effects are estimated using moderated mediation analysis as suggested by Preacher et al (2007) and Muller et al (2005).

1.1 Background of Study

Information Communication Technology (ICT) plays a central role in transition to knowledge-based economies. There is growing evidence that ICT, innovation and technological changes are strong determinants of economic growth. (Jorgenson and Stiroh,

2000). Therefore, ICT's are variety of goods, applications and services used for producing, distributing and transforming information which includes telecoms, hardware, software and computer services (Marcelle G, 2000). The global information technology report (2008-2009) concludes that ICT helps in getting access to markets as well as it has impacts on government efficiency and better communication (Dutta, 2009). Further, ICT is also categorized into information technology (hardware, software), communication (internet, broadband) and telecommunication (mobile phones, landlines).

Empirical research before 1990s shows negative or zero impact of ICT on growth. The reason behind is "Solow paradox" or "Computer paradox". Solow expressed his views as "you can see the computer age everywhere but in productivity statistics" (Solow 1987). Economic literature suggests two explanations of Solow paradox: one is lack of proper data and second is that human capital and economy needs time to adjust with new technology. Later on, studies by Daveri (2002) and Colecchia (2002) find a significant rise in economic growth due to ICT capital in USA (United States of America) and EU (European Union) countries. Further, studies conducted by Jorgenson and Stiroh (2000) find significant effect of ICT on labor productivity and Economic growth. Despite numerous studies, the evidence of ICT contribution in developing countries is still scarce. Dewan and Kraemer (2000) find low impact of ICT in developing countries and reason is low investment in human capital.

ICT affect economic growth by various channels such as foreign direct investment, human capital etc. Studies that have analyzed the role of human capital in growth process fall into two groups. On the one hand some studies focus on the existing stock of human capital that has impact on growth (Nelson and Phelps, 1966). While, on the other hand some studies focus on accumulation of human capital that has impacts on growth and that can be used to show growth differentials across countries (Lucas, 1988). Furthermore, Romer (1990) finds that both stock and growth of human capital help in generating new ideas and in return growth

increases. Most recent empirical analysis use educational attainment as a proxy of human capital. Benhabib and Spiegel (1994) find a positive impact of schooling on growth but Barro and Sala-i-Martin (1995) find no impact of schooling on growth. Moreover, ICT affects human capital in such a way that firms having educated workers can extract more benefits by implementing technologies as shown by Chun (2003), that highly educated workers are likely to implement new technologies such as ICT.

1.2 Theoretical Framework

Most of the economic theories focus on the determinants of growth. Growth can be defined by proximate sources such as labor, capital and technology. These sources are used by most of the traditional theories of growth such as Solow (1956) and Romer (1990) etc. Adam smith in his famous book "Wealth of Nations" says that growth not only depends on capital accumulation but also on technology (Smith, 1776). So if a society is having more access to knowledge, information and technology, it can flourish and get progress in terms of growth. Further Schumpeter (1939) focuses on the role of creating new technical paradigms for future growth in his theory named as Neo-Schumpeterian theory, which is based on technological innovation

ICT infrastructures alone do not result in increase in output of an economy, several internal and external factors mediated the relationship such as foreign direct investment, skilled workers etc (Dewan & Karemer, 2000). It has been argued that complementary investments in human capital are essential to the realization of economic outcome from technological investment (Benhabib & Spiegel, 1994). Many ICT for development researchers (ICT4D) now agree that the lack of attention to complementary investment in human capital is hindering ICT related innovation and productivity in developing economies (Pohjola, 2002). ICT affects human capital in such a way that investment in education and trainings allows a person to improve his skills and innovative capabilities which results in better production for firms

(Black and lynch, 1996). Investment in ICT equipment increases the amount of capital available for labour thus increasing economy wide labour productivity which is likely to increase economic growth, it also help in introducing new technologies into the production process (Brussels, 2006). Moreover, human capital affects economic growth by many ways. For example, by increasing human capital, demand of labor increases and in return employment and output will rise (Abbas, 2000).

Therefore, this study employs moderated mediation analysis to explore the channel of human capital through which ICT may affect economic growth. Further, we explore the conditional effects of ICT on growth, human capital being a conditional variable.

1.3 Significance of the Study

This study is beneficial in many ways: firstly; to enhance growth and to catch-up with developed countries there is a need to focus on the usage of ICT as shown by Koutrompis (2009); that, if broadband (ICT indicator) penetration increases by 10% it results in 0.25% increase in GDP growth. Another study conducted by UNESCO (2010) shows that in case of China if broad band increases by 10%, it results in 2.5% growth in GDP of country. So, there is a need to focus on all determinants of ICT in order to achieve an increase in economic growth because these indicators of ICT are overlooked in the existing literature. Secondly, this study uses the SUR (seemingly uncorrelated regression analysis) model which is the modern econometric method for estimation. Thirdly, we not only study the channel of human capital through which ICT may affect growth but investigate the conditional effects of ICT on growth for different levels of human capital.

1.4 Research Objectives

While taking into consideration the importance of human capital (HC) for examining the relationship among information communication technology (ICT) and economic growth (GROWTH), present study has two objectives

- To investigate comprehensively the impact of information communication technology on growth through the channel of human capital.
- To investigate the conditional effects of information communication technology on growth for different levels of human capital.

1.5 Scheme of the Study

The current research study consists of five chapters. First chapter named as introduction which represents the background, introduction, significance and objectives of the study. Second chapter, consists of different themes of previous empirical literature relevant to the current study. Third chapter, we provide estimation methodology, econometric model, equations of direct and indirect effects and discussion about estimation techniques. Fourth chapter is based on empirical results and their interpretations and the last chapter includes conclusion, policy implications and future areas of research.

Chapter 2

Literature Review

This chapter includes the previous empirical literature related to different factors of economic growth that we use in present study. We discuss both direct and indirect effects of information communication technology on economic growth. At the end of this chapter a brief summary is given.

2.1 Background

There is a huge literature that discusses the determinants of economic growth. Many studies, such as Jorgenson (1995) find that economic growth increases because of increase in physical capital accumulation. Further Solow (1956) focuses more on the role of physical capital accumulation and it takes technology exogenous. Romer (1990) introduces endogenous growth models in which technology is taken as endogenous. Further, he states that "the driving force of growth is knowledge". As far as human capital is concerned, Benhabib and Spiegel (1991) finds that human capital has positive but insignificant effect on growth. However, Temple (1999) shows that there exists a positive and strong relationship among human capital and growth which is very likely to be masked by the presence of outlier observations. Furthermore, the prominent literature on the direct and indirect effects of ICT on economic growth is reviewed in the following subsections.

2.2 Direct impact of information communication technology on Economic Growth

Information Communication Technologies (ICT) plays a central role in transition to knowledge-based economies. Empirical research before 1990's shows negative or zero impact of ICT on growth. The reason behind is "Solow paradox" or "Computer paradox" (detail is given in Appendix). The zero impact of ICT on economic growth is shown by Arsene (2007).

The author examines the impact of ICT on economic growth in Cameroon economy (developing country), Cobb -Douglas production function and cross sectional data for year 2004 is used. The results shows that investment in ICT has no impact on Economic Growth as well as on labor productivity. Since Labor is abundant factor in Cameroon economy which results in relatively low salaries so it is profitable for firms to hier more labors at low salaries but it decreases positive impact on growth.

Similarly, Guetat (2007), use data for the period of 1992-2004 to check the impact of ICT on economic growth of MENA (North Africa and Middle East region) economies including Egypt, Israel, Iran, Jordan etc. The results show no impact of ICT on growth in MENA economies. The author conclude that reason behind no significant impact is lack of human capital and less investment in ICT sector.

On the other hand, some studies show opposite results, as Chowdhury (2002), check the impact of ICT investment on economic performance of small and medium enterprises. The data is taken from three east African economies: Kenya, Tanzania and Uganda. His results show negative effect of ICT investments on labor productivity and growth. Similarly, Loveman (1994) and Brynjolfsson (1996) find negative effect of ICT on economic growth.

Later on, studies such as Brussels (2006), conclude that investment in ICT will increase the capital for labor to work with which in turns increases the labor productivity and growth. They examine the effect of ICT capital on growth for the period 1995-2004 and countries are USA, EU15 and 15 individual states. The findings are in favor of USA because of its higher investment in ICT and it gets more benefit from ICT industry than other countries. Furthermore, Elena (2007), examine the impact of ICT (hardware, software and communication technologies) on economic growth among advanced industrialized economies. They used Non parametric approach by which the elasticity of ICT and human capital is directly estimated. Their research covers the data for the period 1980-2004 of OECD countries.

They also examine whether nonlinear relationship among human capital and growth still exists in presence of ICT effects or not. The results shows that there exists a nonlinear relationship among ICT and productivity and among human capital and productivity.

Similarly, Erdil et al (2009), study the impact of ICT on economic growth for underdeveloped and developing countries. The paper attempts to check the assumption whether ICT is one of the main contributor of economic growth or not? The data is taken from 131 developing (middle income countries) and underdeveloped countries (low income countries). The data is taken from World Development Indicators for the period of 1995-2006. GMM technique is used to check the above assumption. Results are in favor of the given assumption, even in presence of some control variables it gives positive impact on economic growth. Bloom et al (2010), evaluate the productivity miracle of US multinationals. They find that US growth in terms of productivity increases after 1995. Before that a sudden decline in US multinationals is because of oil shock that strikes US economy during 1970. The productivity increases only in those sectors which use IT (technology) excessively. This study uses two micro panel data sets that comprises of US multinationals and non-US multinationals. The findings show that US-multinationals experienced high growth in IT sector than the non-US multinationals. The main reason of this growth is because of strict management policies in US-multinationals.

Moreover, Hollenstein (2004), examine the adoption of ICT by Swiss business sector. The author focus on firm's ability in adopting ICT as well as its indicators such as internet and broadband. Survey based data is used for the year of 2000 for 2600 firms .Two different models are used for estimation: rank model in which heterogeneity among firm's is important for adoption of ICT and epidemic model in which spillover effects are considered among users and non-users. The study overcome the following issues: first, large data set containing more variables and large business sector. Second, empirical model is used containing large number of dependent variables. Third, both inter-firm and intra-firm diffusion is considered. Fourth,

rank model effects are considered. Finally, the role of "new workplace organization" is also considered. Results show that the main problem in adoption of ICT in Swiss sector is lack of knowledge about new technology, managerial issues and lack of finances. The author concludes adoption of ICT reduces firm's cost and helpful in product innovation.

Similarly, Moradi (2010), study the effect of ICT investments on economic growth. The problem addressed by author is whether ICT investments lead to economic growth or not. They uses data of 48 Islamic countries over period of 1995-2005. Standard Solow growth model is used considering speed of convergence, human capital and ICT investment. Results show that ICT capital, and non ICT capital both have positive and significant impact on growth whereas, Inflation show negative impact on growth, openness and population show no impact on growth.

Further, Bayo (2007), examine the determinants of ICT adoption in Spanish firms. The data is taken from 337 Spanish firms for year 2002. Dependent variable is ICT and independent variables include human capital, company size etc. Results show that there is a need to study different variables of ICT. Managers should align firm's strategy and ICT adoption in order to achieve maximum advantage. Furthermore, Samimi et al (2015), study the impact of ICT on economic growth of developed and developing economies. The data is taken from 60 countries for the period of 2001-2012. Cobb –Douglas production function is used. A composite measure of ICT is used which includes opportunity, infrastructure ad ICT related products. Results show positive impact of ICT in both developed and developing economies but larger impact is seen in developing countries because of recent use of ICT. The author conclude that in order to attain more benefit of ICT, there is a need to invest more in developing economies.

Black and Lynch (2004), attempt to check the driver of growth in US economy. The author argues that during 1990's, several factors in workplace contributed positively to economic growth like team management, freedom of speech etc. The data is taken from EQW (educational quality of the workforce) for the period of 1993-1996. Results show that workers

are actively participating at workplace and increase in computer diffusions results in productivity growth. Furthermore, a strong positive correlation is present among workplace and productivity. Further, O'Mahony (2005), study the impact of ICT capital on economic growth of UK and US manufacturing firms. Research at industry level fails to find a positive relationship among ICT capital and economic growth because of heterogeneity among firms. The data for this study is taken from 55 separate industrial sectors, 31 in USA and 24 in UK for period of 1976-2000. Result shows that when data is pooled and dynamic panel data analysis is used, positive effect of ICT on economic growth is seen in both countries whereas, strong positive effect is seen in US and less in UK.

Further, Brynjolfsson (2002), show the effect of computers on productivity and output growth. Two time periods (long run & short run) are used to check the above impact. The data set of 527 US firms is used over period of 1987-1994. Growth accounting framework is used. Results show that during short run benefit from computer is roughly related to its capital cost and only results in increasing output growth but not productivity but when time increases, contribution rises than capital cost and leads to multifactor productivity. Nour (2002), study the effect of ICT on Egypt and Gulf economies. Both countries are less developed in context of ICT. The difference between both countries is that ICT supply is more in Egypt and ICT demand is more in Gulf country. Impact of ICT on economic growth and human capital is positive but ambiguous in both countries. Later on both countries expanded their markets, Gulf countries has comparative advantage in demand because more demand of ICT is there in terms of internet users and telephone users whereas, and Egypt has comparative advantage in terms of supply of ICT goods. The author concludes that combining both market will result in world's largest ICT market.

Moreover, Jorgenson (2005), examine the impact of Information Technology on world's economic growth. The data is taken from 14 major countries over the period of 1989-

2003. The output growth is explained by input growth and productivity. Results show that input growth show more impact. The investment in ICT brings positive result and its impact is greater in industrialized economies and in developing regions of Asia. Developing Asia gives 60% of World economic growth before 1995 and 40% after 199. While china contributes to the half of Economic Growth.

The research conducted by Broad Band Stakeholders Group (2004), examine the role of broadband for British telecommunications where 8500 workers are working at home using broadband in 2004. This setup brings a significant advantage to the company. The company accommodation cost of $6000 is saved by each worker which results in a productivity growth of 15-31%. The advantage of working at home results in Annual savings of $60 million to the company. So the overall analysis show huge positive impact of broadband on productivity. Similarly, Lehr et al (2005), show the positive impact of Broadband on Economy. For their study, different data sets were used such as business activity indicators, demographic indicators etc. Their findings show that between years 1998-2002, a rapid growth in employment, overall business and business in IT intensive sectors is experienced by those communities where mass-market broadband was available by December 1999.

Further, Manyika (2011), observe a positive impact of internet on economic growth. In his paper, he conclude that internet accounts for 3.4% of GDP across large economies and is equal to 70% of global GDP. He further conclude that if internet consumption and expenditure are a sector, its weight in GDP would be bigger than agriculture sector or energy sector.

Similarly, Czernich et al (2009), study the impact of broadband infrastructure on growth. A panel of OECD countries is used for the period of 1996-2007. The instrumental variable (IV) model with its non -linear first stage is used that is derived from the technological diffusion model where already existing cable TV networks and voice telephony lead to maximum effect of broadband. The article attempts to clarify three different issues: first,

individuals that are living in high income economies have the ability to pay more for broadband services which results in better penetration of broadband. Second, economic policies and state intervention might be a hurdle in broadband expansion within a country. Third, the separate effect of broadband is difficult to check because of increase in other technologies such as computers and mobile telephony side by side with broadband. The results show that a 10% increase in broadband penetration increases annual per-capita GDP growth by 0.9-1.5 % points. Both linear and non-linear models results in robust effect of broadband on growth. Choi et al (2009), study the effect of internet on economic growth. Data of 207 countries is used for the period of 1991-2000. Data is taken from World Bank Indicators. They used GMM to check impact of internet on growth. The results show that in the presence of control variables: investment ratio, government consumption ratio and inflation, internet plays a significant and positive role on economic growth.

A survey conducted by Ogunsola (2005), on Nigerian economy explains the historical development of telecommunication in Nigeria. The first satellite through which Nigeria connects the outside world is Lanlate 1. He focus on the importance of telecommunication as an international priority and conclude that advancement in ICT is a revolution in Nigerian economy. Similarly, Holt et al (2009), discuss the relationship between communication technologies and economic growth. The paper emphasis on the importance of telecommunication by using various literature surveys conducted on US economy. They find a positive impact of telecommunication on US economy. Their findings conclude that during 2009, much faith is seen in this sector by government as US congress approved 7.2 million to expand this sector.

Moreover, Breshnan (2002), examine the relationship between IT, workplace organization and the demand of skilled worker. The data is taken from firms for the period of 1987-1994. It covers approximately 400 large US firms from which 55% belongs to

manufacturing sector and 45% are from services. The findings show that managers that use IT brings innovations in their organizations which further include de-centralized decision making and self-managing teams etc. In return the technology and organization are associated with worker's skill. So both IT and IT enabled organizational change is an important factor of skill-biased technological change.

Further, Daveri (2002), study the impacts of technology in Europe. He observed that after 1990s, most of the European Union economies show growth in IT (information technology) sector. Earlier this sector results in little or no productivity gains in Europe. Later on, a sudden rise is seen in terms of IT (information technology) productivity in six European Union countries (includes UK, Denmark, Finland, Sweden, Ireland and Greece) but European Union as a whole lag behind from US in terms of IT (information technology) productivity.

Furthermore, Roller and Waverman (2001), examine the impact of telecommunications infrastructure on growth. They focus on the creation of "Super highways" and its potential impacts on the economy. The author observed that when an economy has less access to telephone system, it result in poor communication between firms and high cost in terms of transaction cost, cost of ordering goods etc. if telecommunication improves, it give benefit to firms as well as economy. Telecommunication provides network externalities: more users, more benefit is taken by those users. Data of 35 countries is used for the period of 1970-1990 which includes 21 OECD and 14 Developing countries. Result shows positive causality among telecommunication and economic growth, high growth effect is seen in OECD countries and less in non OECD.

2.3 The Relationship between Human Capital and Information Communication Technology

Researchers find that investment in ICT alone does not lead to an increase in the revenues of the country, several other factors are required to mediate the relationship and one

of the main factor is complementary investment in human capital. Samoilenko (2011), explain that human capital is one of the major factor that effect ICT in Transition Economies. He attempt to explore the complementary between ICT and human capital. Panel data of eight transition economies is used for two consecutive time periods: 1993-1997 and 1998- 2002. Multivariate regression and DEA technique is used to conduct data analysis. The result shows that when the interaction term of investment in ICT and labor is negative, so need to invest more in skilled worker and when the interaction term of investment in ICT and ICT staff shows a positive sign then invest more on ICT investment.

Further, Murphy (2007), check the impact of human capital in ICT industries. The data is taken from 20 OECD countries for the period of 1980-2002. 54 countries are used for the analysis. Structural equation model is used for the estimation. Results show that countries having high human capital stock gives high growth in their ICT industries. Whereas, post-human capital stock and ICT helps in growth relatively more than other economies.

Similarly, Castel et al (2007), attempt to check the impact of complementary factors on growth and emphasis more on the role of human capital on Spanish firms. There is a lack of research on the above relationship for Spanish firms. The data of 1225 Spanish firms is taken from Survey on Business Strategies to check impact of ICT and complementary investment on productivity growth. They test three hypothesis related to ICT: ICT with complementary factor, management attitude and innovation. Their Results show that ICT investment has profound impact on output when it is complemented with skilled worker and when firms have agreements regarding management (adoption of new technologies, wage structure) then ICT results in maximum efficiency of workers. Overall they conclude that not only human capital (skilled workers) rather adoption of new technology and firm's management is also important to have better results of ICT on productivity.

Furthermore, Hempell (2003), examine whether ICT and training programs of firm are complementary or not? The author explain that it is beneficial for firms to conduct on job trainings because hiring of educated worker and skilled worker is costly. The paper try to address following issues: to check the link between ICT investment and the need of training at firm's level, to check whether investment of firm in ICT leads to productivity gains or not? And the role of education. The data is taken from German service companies for the period of 1994-1998. GMM is used for estimation. Results show that ICT investment not only compel firms to invest more in human capital rather it brings incentives for firms to conduct training programs. When ratio of productive workers increases, it result in productive gains to firms. The author concludes that training programs and ICT are complementary but the productivity of worker depends more on formal education.

2.4 Direct Impact of Human Capital on Economic Growth

Human capital is always considered to be a major contributor of economic growth. Literature show two schools of thought regarding the impact of human capital on growth. One school of thought focus on the existing stock of human capital which only show impact on growth (Nelson and Phelps, 1966). While, the other focus on accumulation of human capital that gives effect on growth as well as it show growth differentials across countries (Lucas, 1988). Furthermore, Romer (1990) find that both stock and growth of human capital will help in creating new ideas and in return growth will increase. Similarly, Qadri (2011), explore the relationship among human capital and economic growth on Pakistan's economy. Generally human capital is considered to be the major contributor of economic growth. The data covers the period of 1978-2007. Cobb-Douglas production function is used to analyze the relationship. The study use education as a proxy of human capital. Result of study confirms the findings of literature that human capital contributes positively to economic growth and its indicator is

highly significant. The author suggested that policy makers should invest more on education sector in order to achieve economic growth.

Further, Mankiw et al (1992), analyze the effect of human capital on economic growth. They attempt to examine Solow model with and without human capital. The data set of 121 countries over the period of 1960-1985 is taken. The dependent variable is output growth whereas labor, education and physical capital are independent variables. School is taken to be the proxy of human capital. Findings of the study show that Solow model with human capital explains 80% of income variation across countries. Later on, this framework is recommended for various studies.

Furthermore, Bernanke (2001), analyze the framework recommended by Mankiw (1992) to check the impact of human capital on economic growth. His study use annual data set of 121 countries over the period of 1960-1995. Cobb-Douglas production function is estimated by applying OLS technique. School is taken to be the proxy of human capital. Findings of the study show that long run growth is not related to human capital and it is related to behavioral variables like saving rate etc. So the study confirms that long run economic growth is endogenous.

Moreover, Abbas (2000), compare the effect of human capital on economic growth of Pakistan and India. A data set of 25 years is used over the period of 1970-1994. Growth accounting framework and OLS is used for estimation. Dependent variable is growth and labor, human capital, physical capital are independent variables. The proxy used for human capital is enrollment rate at different levels. Results show that secondary education is significant in both countries whereas primary education is significant in India at 1% level of significance and higher education is significant in Pakistan at 10% level of significance. Similarly, Abbas (2001), examine the effect of human capital on economic growth of Sri-Lanka and Pakistan. Standard human capital Augmented production function is used. Annual data set over the

period of 1970-1994 is used. Enrollment rate at different levels is used as a proxy of human capital. OLS is used for estimation. Results show that secondary and higher education is significant in both countries but at different levels of significance, at 1% level of significance for Pakistan's economy and at 5% level of significance for Sri-Lankan economy.

Further, Duma (2007), study the driver of economic growth on Sri-Lankan economy. They used Annual data set over period of 1980-2006. Human capital Augmented cobb-Douglas is used having output growth as dependent variable, physical capital, labor and human capital are independent variables. Total factor productivity is residual in the equation which captures the unexplained changings in output. Findings of the study show that human capital has a low impact on economic growth and it contributed only 10% of economic growth. While labor and physical capital contributed 27% and 17% to economic growth. The surprising result is that TFP contributed 46% to economic growth. The author conclude that the reason of low human capital is a decline in labor-intensive commodities after 1980's. Therefore TFP explains major portion of rise in growth.

Furthermore, Abbas and peck (2008), examine the effect of human capital on economic growth of Pakistan. The data set covers the period of 1961-2003. Stock of human capital and health expenditures are used as a proxy of human capital. Co- integration technique is used to estimate the effect. Findings of the study show that investment in health sector brings an increasing return to human and physical capital. Madsen (2008), explore the effect of human capital on economic growth of India. Data covers the period of 1993-2005 for 590 firms. Human capital Augmented production function and Co-integration is used for estimation. Findings of their study show that Indian growth is in line with Schumpeterian and a long run relationship is present among research and product innovations rather than TFP and research.

Moreover, Zhang (2011), examine the effect of human capital on economic growth of china. The data is taken from 31 provinces of china over period of 1997-2006. Enrollment rate

at different levels is used as a proxy of human capital. Generalized Measured of Moments is used to measure the impact. Results show that higher education is significant and it exerts positive impact on economic growth. The author conclude that the impact of higher education is more in developed provinces and under developed relies more on primary education.

2.5 Summary

Overall, the above discussion shows that ICT is an important determinant of economic growth which has direct as well as indirect impacts on growth. However, present study construct a composite measure of ICT using various indicators of ICT such as broadband subscriptions, internet users, mobile cellular subscriptions etc. These indicators of ICT are overlooked in literature. So there is a need to focus on all indicators of ICT in order to check their impact on growth. Further, to check indirect effects by using a channel of human capital.

A brief review of the literature reflects different stances regarding direct and the indirect relation of ICT, human capital and economic growth. There are various channels through which ICT may effect economic growth like foreign direct investment, training programs carried out by managers etc. The important and crucial channel through which ICT affects economic growth is human capital, it effects in a way that investment in human capital, manager's strategy in adopting new technology, on job trainings results in better production in ICT industries as viewed in literature. The effect of ICT on economic growth through the channel of human capital is scarce and rarely found in literature for developing countries. A composite measure of ICT is not used in literature so there is a need to construct index of ICT and then to check its impact on countries, especially developing countries. Another reason is that ICT is relatively a new phenomenon in developing countries so its impact could be more in these countries.

Chapter 3

Data and Empirical Methodology

The chapter consists of data, empirical methodology and description of variables. It also includes equations which indicate direct and indirect relationships among the dependent and independent variables. At the end of this chapter, SUR model is discussed, that we use for the estimation of our econometric model. Further, graphs and scatter plots reflecting relationship between variables are also discussed.

3.1 Data and Variables

The variables which we use in this study are discussed in this section. We use a panel data set of three year averages for selected developing countries over the period of 2000-2014. We use panel data because it allows us to address crucial economic questions, which time series and cross sectional data cannot. Furthermore, panel data with larger data points increase the efficiency of economic models and it also controls the effect of omitted or unobserved variables (Wooldridge, 2001).We use panel data set to see the impact of ICT on economic growth through the channel of human capital. The selection of countries and time period is dictated by information communication technology (ICT) and human capital (HC) data.

Our dependent variable is economic growth (GROWTH) which is log difference of real per capita GDP. We have two main independent variables, that is, Information Communication Technology (ICT) and human capital (HC). We will use HC as a channel through which ICT may affect economic growth. Further, it is also used as a conditional variable. We use average years of schooling aged up to 15 years as a proxy of human capital (HC). We will use initial per capita GDP in growth regression to control for convergence. The other control variables are inflation (INF), trade openness (OPEN), investment (INV), government size (GOV) and per capita income (PCI) measured as GNI per capita Annual %.

The study uses three main indicators[1] of Information communication technology (ICT), namely fixed telephone subscriptions (FTS), mobile cellular subscriptions (MCS) and internet users (IU) to construct a composite measure of ICT(detail of ICT index is given in Appendix) using principal component analysis (PCA). The definition construction and data sources of these indicators and all other variables is given in Appendix, Table A1.

3.2 Principle Component Analysis (PCA)

The correlation matrix of indicators of information communication technology (ICT) in each dimension show that these indicators are correlated with each other. In order to convert the correlated indicators into a linearly uncorrelated indicators, we use Principal Component Analysis (PCA). The PCA is considered to be the most common form of factor analysis. There are several advantages of PCA, it helps to develop new variables or dimensions that are linear combination of the original one ,uncorrelated with one another and captures as much of the original variance in the data as possible. First principal component analysis is used when greater number of variation is present in the original data set; it reduces irrelevant and brings out most important ones (Hristova, 2012). Therefore, we use PCA method to construct a composite measure of ICT indicators to avoid any possible multicollinearity that may arise by including many ICT indicators in one regression.

3.2.1 Principle Component Analysis for ICT

Table A2 in Appendix shows that information communication technology indicators IU and MCS have a correlation coefficient of 0.70 , FTS and MCS have a correlation coeffecient of 0.35 Whereas, FTS and IU have a correlation coefficient of 0.64. PCA[2] is used to convert the correlated indicators of ICT into uncorrelated indicators, and to make a

[1] There are also other measures of ICT like broadband subscriptions, international internet bandwidth and household with television, but our study is focusing on three important indicators of ICT, named under category of ICT access, mainly due to problem of data availability.

[2] The detail description of PCA is given in Appendix

composite measure of ICT. Table A3 in Appendix shows the results of ICTPCA using three main indicators of ICT, namely FTS, MCS and IU. Results show that only first component analysis is relevant because it has an Eigen value of 2.14 which is greater than 1.Therefore, we use the weights of first principal component tin order to construct an index for information communication technology (ICT). Scree plot (Graph-1 in Appendix) for eigenvalues also confirms that the first principal component explains almost 22 percent of the variation in the data, more than the other two components. Therefore, our composite measure of information communication technology (ICT) is constructed using the following equations.

ICT (index) = 0.53*FTS +0.55*MCS +0.64*IU

Where, FTS shows fixed telephone subscriptions for ith country, MCS shows mobile cellular subscriptions for ith country and IU shows internet users for ith country. Squared loadings are used in the above equation in order to have a nominal coefficient value. The above equation is used to construct a series of ICT. The lowest point of ICT index is 0 which indicates minimum usage of ICT in the respected country whereas the highest point that is given to ICT index is 8 which indicates the maximum usage of ICT in the particular country.

3.3 Descriptive Analysis

In this section we will discuss the descriptive analysis of our research. We incorporate summary statistics, correlation matrix of all variables and some graphical plot to demonstrate the correlation among key variables of the study.

3.3.1 Summary statistics

Summary statistics of this study represents the number of observations of all variables, mean values of all variables, maximum values and minimum values of each variable and standard deviations of all the variables of research. Similarly, summary statistics show that how many values of each variable deviate from their mean value. In this study the main variables

like economic growth (GROWTH) and information communication technology (ICT) have the number of observations 220. Similarly, the mean values of these two variables are 3.08 and 7.98 respectively. While, the standard deviations of these two variables are 2.60 and 1.21 respectively. On the same basis maximum values of GROWTH and ICT are 12 and 9, and minimum values are -3.9 and 4 respectively. We see that Y0, PCI and OPEN are three variables having large values of standard deviation. The large value of the standard deviations shows that these three variables have more deviation from their mean values which creates disturbance in the variables of research. Similarly, the smallest values of standard deviations of HC, ICT and GROWTH describes less deviations from their mean values which means that these values causes minor disturbance in other variables of research. Table of summary statistics is presented in the Table A4 in Appendix

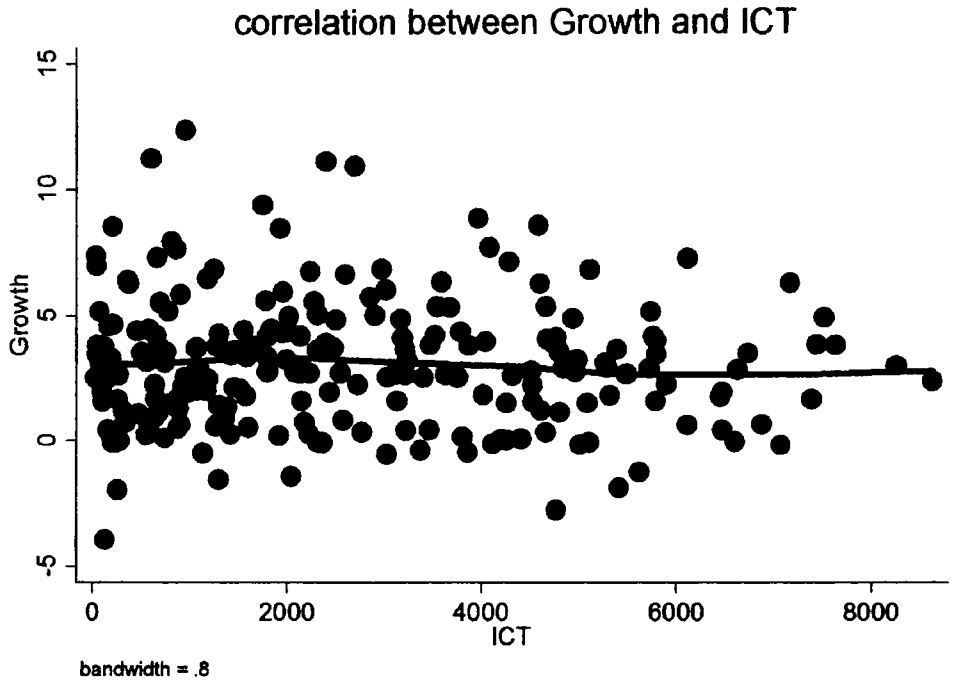
3.3.2 Correlation Matrix

Correlation matrix in the descriptive analysis is based on the relationship of each variable with other variables of the study. But the table of our correlation matrix describes the relationship among two variables separately and the diagonal represents the 100% correlation of each variable with its own. In this matrix we observe the positive relationship among our main variables economic growth (GROWTH) and human capital (HC) that is 0.1172. In the same way, correlation among economic growth (GROWTH) and information communication technology (ICT) is -0.06. Similarly, we see that there is positive correlation between human capital (HC) and information communication technology (ICT) that is 0.55.If the significance level of all the variables are up to the mark then we have no concern with the strength and magnitude of the relationship between the variables as we are interested in inferential analysis. Correlation matrix is given in Table A5 in Appendix.

Further, our scatter plot of ICT and GROWTH is shown in fig 3.1

Figure 3.1 Correlation between Growth and ICT

The given figure represents the relationship among information communication technology (ICT) and economic growth (EG).

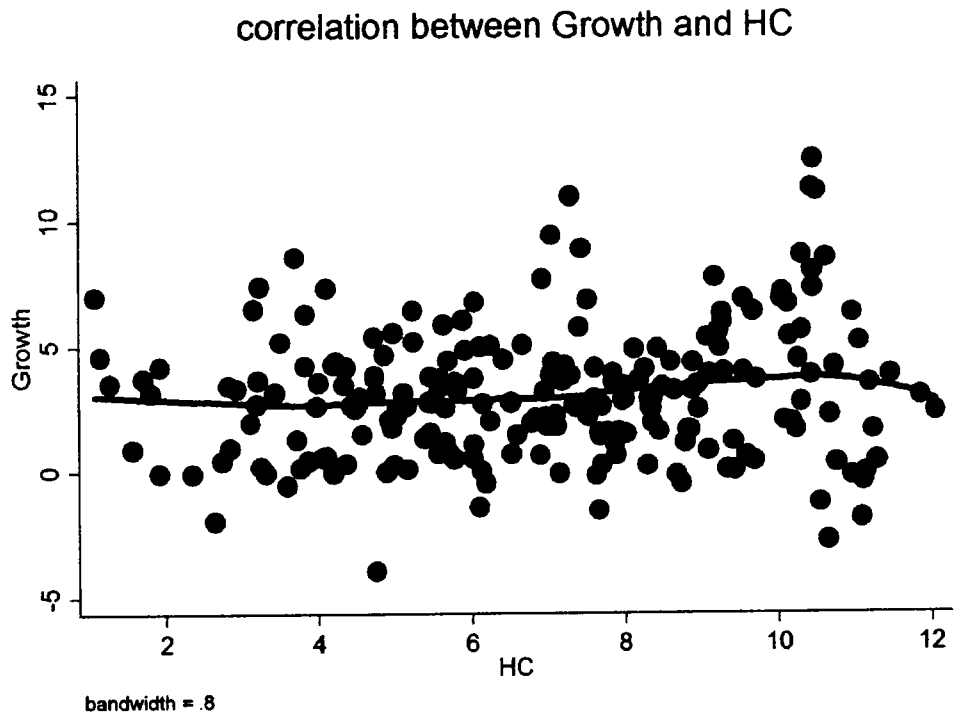


Economic Growth (GROWTH) and Information Communication Technology (ICT) are the core variables in our study. We observe a nonlinear relationship between these variables. Initial level of Growth is stable against the level of ICT, Growth decreases as the level of ICT increases. After a certain point a bit of rise is seen in growth due to increase in ICT. Similarly, this diagrammatic representation describes negative relationship between ICT and economic growth.

Similarly, our scatter plot of GROWTH and HC is shown in fig 3.2

Figure 3.2 Correlation between Growth and Human Capital

The following figure demonstrate the relationship among human capital (HC) and economic growth (GROWTH).

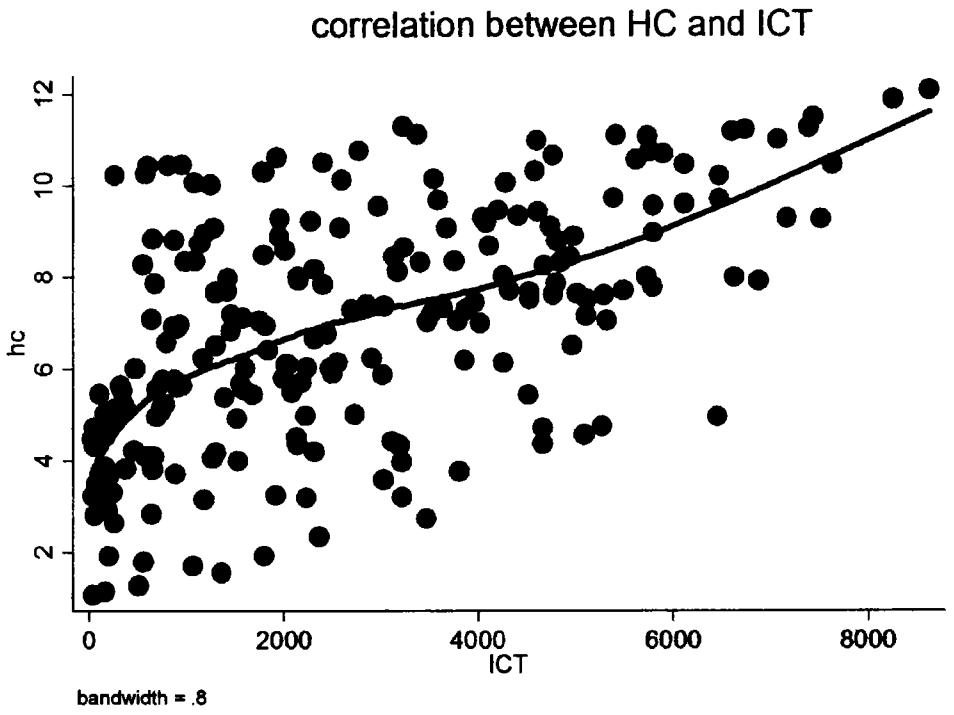


The diagram demonstrates the relationship among Economic Growth (GROWTH) and human capital (HC).There is a non-linear relationship between human capital and economic growth. It shows that when human capital increases, it leads to increase the growth up to a certain point and then it starts declining. So, a positive relationship is present between human capital and economic growth. Although this relation is not strong enough but it is positive so, we can say that a good level of human capital can lead to enhance economic growth.

Further, our scatter plot of HC and ICT is shown in fig 3.3

Figure 3.3 Correlation between HC and ICT

The following diagram demonstrate the relationship between human capital (HC) and information communication technology (ICT).



Human capital (HC) and information communication technology (ICT) are the core variables n our analysis. We observe a non-linear relationship among these variables. As the level of information technology grows, initially level of human capital increases with a decreasing rate but after a certain point it starts increasing with an increasing rate. So, positive relationship between human capital and information communication technology is present.

3.4 Estimation methodology

In this section, we discuss our estimation model and estimation method.

3.4.1 Model

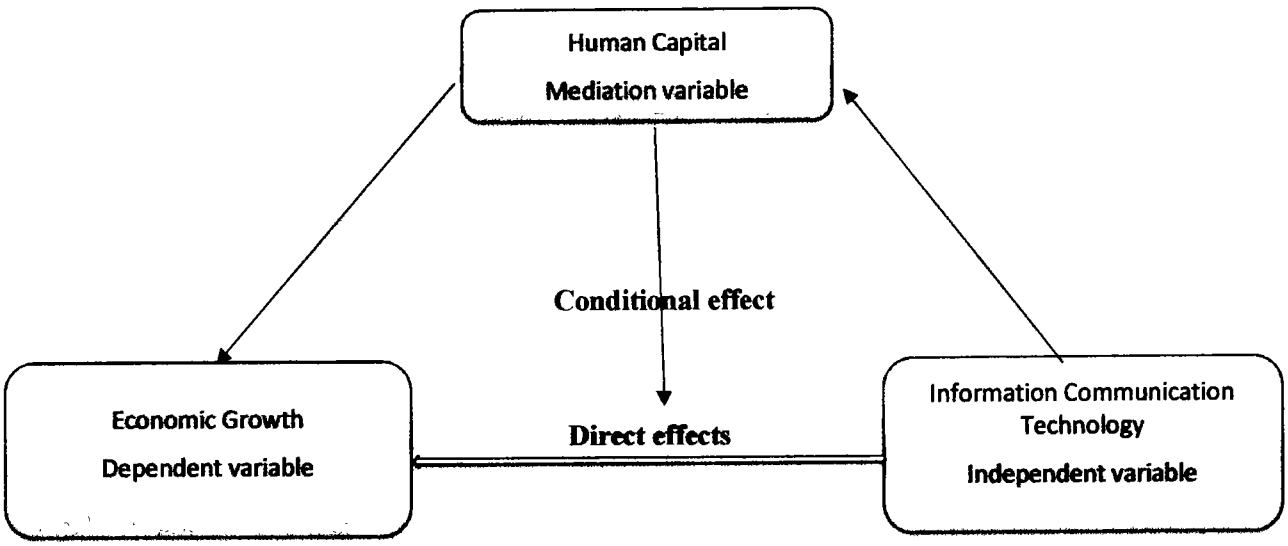
In order to investigate the relationship between variables which are economic growth (GROWTH), human capital (HC) and information communication technology (ICT), Moderated mediation analysis is applied as suggested by preacher et al. (2007) and Muller et al (2005). This method explains the impact of mediating and moderating variable between two variables. In this study dependent and explanatory variables are economic growth (GROWTH) and information communication technology (ICT) respectively. Information communication technology (ICT) affects economic growth (Growth) indirectly through the channel of human capital (HC). So, human capital (HC) is playing role as a mediating variable in the model. Further, it also plays its role as conditional variable. We can examine the effect of information communication technology on economic growth either directly or indirectly. To find the indirect effect of information communication technology on economic growth we link information communication technology (ICT) with economic growth through human capital (HC).

In the empirical methodology, we first introduce schematic model to show the direct as well as in direct effects of information communication technology (ICT) and economic growth (GROWTH).

3.4.1.1 Schematic Model

The following figure reflects the schematic flow. We see that ICT affects economic growth directly as well as indirectly: indirect relationship is shown through the channel of human capital

Fig 3.4 Schematic Diagram



The schematic diagram shows that ICT is affecting growth in two ways: first, ICT affects economic growth directly and on the other hand, ICT affects economic growth indirectly through the channel of human capital where human capital is playing a role of mediation variable. Similarly, human capital is playing role of moderator variable between explanatory variable ICT and economic growth (EG). Moderation effects can be shown through the interaction of ICT and HC which is also termed as conditional effect. Detail of moderated mediation is given in Appendix. In order to estimate these direct, and indirect effects following econometric equation will be used.

$$HC_{it} = \alpha_0 + \alpha_1 ICT_{it} + \alpha_2 PCI_{it} + u_{it} \quad (3.1)$$

$$GROWTH_{it} = \gamma_0 + \gamma_1 HC_{it} + \gamma_2 ICT_{it} + \gamma_3 (ICT^{*} HC)_{it} + \alpha_4 z_{it} + \in_{it} \quad (3.2)$$

whereas, HC is human capital measured by average year of schooling of population aged up to 15 years, ICT is an index of Information, communication and technology, PCI (per capita income) is control variable of human capital (HC) equation measured by GNI. GROWTH is real per capita GDP annual growth of a country. HC is level of human capital for each country

and we use average years of schooling of population aged up to 15 years as a proxy of human capital. ICT is an index constructed by using Principal Component Analysis. ICT*HC is interaction term of ICT index and HC, Z is a vector of control variables in GROWTH regression that includes initial real per capita GDP (YO), trade openness (OPEN), Inflation (INF), Government size (GOV), and Investment (INV). α_0 and γ_O are the intercept terms that shows random effects of the regressions, α and γ are vectors of coefficients of explanatory variables, u and ε are stochastic error terms, i is for country and t shows time period.

The system of above equations will be estimated using seemingly unrelated regression (SUR) method for unbalanced data as suggested by Biorn (2004).

Indirect and conditional effect of Information Communication Technology (ICT) on Growth through the channel of human capital

We calculate the indirect effects of ICT on growth through the channel of human capital from the above two regressions (3.1), (3.2) as follows:

$$\frac{\partial \text{GROWTH}}{\partial \text{ICT}} = \frac{\partial \text{HC}}{\partial \text{ICT}} \text{X} \frac{\partial \text{GROWTH}}{\partial \text{HC}} \qquad (3.3)$$

$$\frac{\partial \text{GROWTH}}{\partial \text{ICT}} = \alpha_1(\gamma_1 + \gamma_3 ICT) \qquad (3.4)$$

$$\frac{\partial \text{GROWTH}}{\partial \text{ICT}} = \gamma_2 + \gamma_3(HC) \qquad (3.5)$$

From equation (3.1) and (3.2) we calculate equation (3.3) which indicates partial indirect effect of ICT on GROWTH and at R.H.S of equation (3.3).firstly, ICT affects HC and then HC affects GROWTH. To calculate the equation (3.4) at first, we partially differentiate equation (3.1) with respect to ICT and get α_1, secondly, we differentiate equation (3.2) with respect to HC and get $(\gamma_1 + \gamma_3 ICT)$. Finally, we multiply both terms to get equation (3.4) which represents the indirect effect of ICT on GROWTH and we get $\alpha_1(\gamma_1 + \gamma_3 ICT)$

The signs of above mentioned indirect effects depend upon the signs and magnitudes of $\alpha_1, \gamma_1 and \gamma_3$. Further, in order to calculate the conditional effects we take the derivative of equation 3.2 with respect to ICT and we get $\gamma_2 + \gamma_3(HC)$

3.4.2 Seemingly Unrelated Regression (SUR) Model

SUR model is proposed by Zellner (1962). It is a generalization of linear regression model. It is based on several regression equations and each equation contains its own dependent variable and different exogenous explanatory variables. It is known as seemingly unrelated because every equation is estimated separately and every equation is a valid linear regression. One of the assumption of this model is that error terms are correlated across the equations but uncorrelated across time.

SUR model can be seen as simple form of General Linear Regression Model. This model can also be generalized into simultaneous equation model, where explanatory variables can be put as explained variables. This technique is already used in previous empirical literature where variables have been used as a mediator or channelized to create indirect links between different variables. We will use this estimation technique in our analysis for unbalanced[3] panel data as suggested by Biorn (2004), detail is given in Appendix.

[3] Unbalanced panel data is, where individual time series have unequal lengths.

Chapter 4

Results and Discussion

This chapter demonstrates estimation outcomes, results interpretations and discussions of outcomes. We divide this chapter into two sub-sections: Sections 4.1 consist of direct, indirect and conditional effects of information communication technology (ICT) on economic growth (GROWTH) through the channel of human capital (HC) using general and parsimonious model. Section two 4.2 presents general discussion of empirical findings.

4.1 Estimation

We categorize our estimation results into two sub sections. Subsection 4.1.1 explains our general model which includes results of the direct, conditional and indirect effects of information communication technology (ICT) on economic growth (GROWTH) through the channel of human capital (HC). Some other control variables like government final consumption expenditures (GOV), investment (INV), inflation (INF), trade openness (OPEN), per capita income (PCI) and initial year per capita GDP (YO) are included.

Similarly, Subsection 4.1.2 explains our parsimonious or specific model which indicates direct (marginal), conditional and indirect effects of information communication technology (ICT) on economic growth (GROWTH) through the channel of human capital (HC). Here we transform our general model into a parsimonious model. In doing so, we exclude the insignificant control variables one by one and again run the regression. We proceed this procedure up to the point where overall significance of the model is achieved. In this study we are left with a model in which we two control variables are present.

4.1.1 General Model

Table 4.1, Model (1) represents our general model that shows the effect of ICT on economic growth (GROWTH) through the channel of human capital. We observe that economic growth (GROWTH) equation explains the effect of initial real per capita GDP (YO), government final consumption expenditures (GOV), inflation (INF), investment (INV) and trade openness (OPEN).

Further, initial real per capita GDP (YO) shows negative but significant effect on economic growth (GROWTH) at 1% significance level which confirms that convergence exists in our study. This result is in line with the theory and prior literature, like studies of Barro (1996), Bleaney and Nishiyama (2000) and Doppelhofer (2000). In our analysis, coefficient value is big, so we can say that the relation is quite strong.

Similarly, the equation of human capital represents the effect of information communication technology (ICT) on human capital (HC). The effect is positive and significant at 1% significant level in Table 4.1, Model (1). It further confirms that there is a positive effect of ICT on human capital (HC) and as the level of ICT increases it will lead to improve the level of human capital in such a way that when increased amount of ICT capital is available for labor to work with, it will increases labor productivity. This result is consistent with studies of Black and Lynch (1996), Brussels (2006) and Doms et al (1997), where they suggest that improved form of technology compels workers to adapt new skills in order to make use of that technology and in return increases labor productivity.

Furthermore, equation of human capital represents the effect of control variable per capita income (PCI) on human capital (HC). The effect is positive and significant at 1% level of significance in Table 4.1, Model (1). It further shows that there is a strong positive effect of per capita income (PCI) on human capital (HC) and as the level of PCI increases it will lead to

Table 4.1 The Effect of information communication technology (ICT) on Economic Growth (GROWTH) through the channel of human capital (HC).

VARIABLES	MODEL (1) General Model	
	LHC	GROWTH
LICT	0.4538 (0.000)***	-7.2155 (0.000)***
LHC		144.54 (0.000)***
LHCICT		0.28020 (0.029)**
Yo		-29.86528 (0.000)***
LPCI	0.2000 (0.000)***	
LINV		1.6968 (0.000)***
LOPEN		0.76051 (0.053)*
LGOV		0.63837 (00.243)
INF		0.1108 (0.460)
Observations	220	220
No. of Countries	44	44

Note P-value of each coefficient is given in parentheses. *, ** and *** show the significance level at 10%, 5% and 1% respectively. Our dependent variables are as follows: GROWTH is growth rate of real per capita GDP. LHC represents log of human capital, taken as an average years of schooling (age 15 years and above). Explanatory variables of our model are describes as follows: LICT is log of information communication technology which is constructed using principal component analysis. LYo is log of initial real per capita GDP. LINV is log of gross fixed capital formation as % of GDP. LGOV is log of the general government final consumption expenditures. LHCICT is interaction tern of information communication technology and human capital. LPCI is log of per capita income taken as GNI (gross national income). INF is inflation (CPI). LOPEN is log of trade openness as a % of GDP.

improve the level of human capital either in terms of improvement in living standards, better education, and better jobs or in terms of productivity. This result is consistent with the prior studies of Melike et al (2005)

On the same basis, equation of growth represents the positive and significant effect of human capital on economic growth (GROWTH) at 1% level of significance in Table 4.1, Model (1).The relationship is positive and strong because the coefficient is having a large and positive value. This result is in consistent with prior studies like Murphy (2007), Abbas (2001) and Qadri (2011). The results of these studies confirms that as the level of education increases, it exerts positive and significant impact on economic growth.

Likewise, equation of growth shows that the interaction term of ICT and human capital LHCICT is positive and significant at 5% level of significance in Table 4.1, Model (1). It shows that negative effect of ICT on economic growth (Growth) decreases as the level of human capital increases. In other words, we can say that negative effect of ICT on GROWTH is less profound in countries having high level of HC.

Furthermore, equation of growth shows the direct effect of ICT on economic growth which is negative and significant at 1% level of significance in Table 4.1, Model (1). It shows that alone ICT do not have a positive impact on GROWTH. As the level of technology increases, economic growth declines and these results are consistent with prior studies like Chowdhury (2002), Loveman (1994) and Brynjolfsson (1996).

In Table 4.1, Model (1), We study the marginal and conditional effects of ICT on GROWTH but the indirect effects of information communication technology on economic growth through the channel of human capital can be evaluated by calculating equations (3.1and 3.2) given in chapter 3. The indirect effect of ICT on GROWTH through the channel of human capital for general model is given in Table 4.2. We differentiate the indirect impacts of ICT on

growth by categorizing ICT into low level, average level and high level of ICT, whereas, coeffecients, p-values and 95% confidence interval values are given in parenthesis.

Table 4.2 The indirect effect of Information Communication Technology (ICT) on Economic Growth (GROWTH) through the channel of Human Capital (HC)

Channels	Levels of ICT	Indirect Effects	95% confidence interval	
Human Capital	Low Level of ICT	6.4835 (0.000)***	5.1443	7.8227
	Average Level of ICT	6.4914 (0.000)***	5.151095	7.8317
	High Level of ICT	6.4970 (0.000)***	5.1559	7.8382
Note: P-value of each coefficient is given in parentheses. *, ** and *** represents the significance level at 10%, 5% and 1% respectively. Low level means 25th percentile, Average level means 50th percentile and High level means 75th percentile of Information Communication Technology (ICT) respectively.				

We observe that the indirect effects of ICT through the channel of HC at low level of ICT is 6.4835, at average level of ICT is 6.4914 and at high level of ICT is 6.4970. The effects at all three levels of ICT are positive and significant at 1% level of significance. The above results suggest that HC does play an important role in defining the effect of ICT on GROWTH in case of 3 years averages data.

We further see that investment (INV) and openness (OPEN) both have significant and positive effect on economic growth (GROWTH) at 1% and 10% respectively. This outcome reveals a positive relationship between investment (INV) and economic growth suggesting that as the level of investment increases it will lead to affect economic growth positively. This result is in consistent with prior studies of (Mankiw et al, 1995) and (Barro and Sala-i-Martin, 1995).

Similarly, the positive relationship between OPEN and GRWOTH means that trade openness affects economic growth in such a way that it increases competition and allows for transfer of knowledge and technology (Dollar, 1992).

We summarize our general model results, there are two variables which are insignificant. For instance government size should affect economic growth either positively or negatively as its impact is inconclusive and same is the case with inflation. But both variables are insignificant in our general model. Therefore in specific model we will exclude these two insignificant control variables one by one and run the regression again and again up to the point where we get a model showing the overall significance and signs of coeffecients also supports the theory.

4.1.2 Parsimonious or Specific Model

In our final model, we exclude all the insignificant variables that are present in our general model. Inflation (INF) and government final consumption expenditures (GOV) are excluded and investment (INV), openness (OPEN), real per capita GDP (YO) are present in our parsimonious model. All the outcomes of our analysis are expressed in Table 4.3, Model (1)

Further, initial real per capita GDP (YO) shows negative but significant effect on economic growth (GROWTH) at 1% significance level which confirms that convergence exists in our study. This result is in line with the theory and prior literature, like studies of Barro (1996), Bleaney and Nishiyama (2000) and Doppelhofer (2000). In our analysis, coefficient value is big, so we can say that the relation is quite strong.

Similarly, the equation of human capital represents the effect of information communication technology (ICT) on human capital (HC). The effect is positive and significant at 1% significant level in Table 4.3, Model (1). It further confirms that there is a positive effect

of ICT on human capital (HC) and as the level of ICT increases it will lead to improve the level of human capital in such a way that when increased amount of ICT capital is available for labor to work with, it will increases labor productivity. This result is consistent with studies of Black and Lynch (1996), Brussels (2006) and Doms et al (1997), where they suggest that improved form of technology compels workers to adapt new skills in order to make use of that technology and in return increases labor productivity.

Furthermore, equation of human capital represents the effect of control variable per capita income (PCI) on human capital (HC). The effect is positive and significant at 1% level of significance in Table 4.3, Model (1). It further shows that there is a strong positive effect of per capita income (PCI) on human capital (HC) and as the level of PCI increases it will lead to improve the level of human capital either in terms of improvement in living standards, better education, and better jobs or in terms of productivity. This result is consistent with the prior studies of Melike et al (2005).

On the same basis, equation of growth represents the positive and significant effect of human capital on economic growth (GROWTH) at 1% level of significance in Table 4.3, Model (1).The relationship is positive and strong because the coefficient is having a large and positive value. This result is in consistent with prior studies like Murphy (2007), Abbas (2001) and Qadri (2011). The results of these studies confirms that as the level of education increases, it exerts positive and significant impact on economic growth.

Likewise, equation of growth shows that the interaction term of ICT and human capital LHCICT is positive and significant at 10% level of significance in Table 4.3, Model (1). It shows that negative effect of ICT on economic growth (Growth) decreases as the level of human capital increases. In other words, we can say that negative effect of ICT on GROWTH is less profound in countries having high level of HC.

Table 4.3 The Effect of information communication technology (ICT) on Economic Growth (GROWTH) through the channel of human capital (HC).

VARIABLES	MODEL (1) Parsimonious Model	
	LHC	GROWTH
LICT	0.04513 (0.000)***	-6.9888 (0.000)***
LHC		143.29 (0.000)***
LHCICT		0.21037 (0.066)*
LYo		-29.499 (0.001)***
LPCI	0.20063 (0.000)***	
LINV		1.7033 (0.000)***
LOPEN		0.7947 (0.044)**
LGOV		
INF		
Observations	220	220
No. of Countries	44	44

Note P-value of each coefficient is given in parentheses. *, ** and *** show the significance level at 10%, 5% and 1% respectively. Our dependent variables are as follows: GROWTH is growth rate of real per capita GDP. LHC represents log of human capital, taken as an average years of schooling (age 15 years and above). Explanatory variables of our model are describes as follows: LICT is log of information communication technology which is constructed using principal component analysis. LYo is log of initial real per capita GDP. LINV is log of gross fixed capital formation as % of GDP. LGOV is log of the general government final consumption expenditures. LHCICT is interaction tern of information communication technology and human capital. LPCI is log of per capita income taken as GNI (gross national income). INF is inflation (CPI). LOPEN is log of trade openness as a % of GDP.

Furthermore, equation of growth shows the direct effect of ICT on economic growth which is negative and significant at 1% level of significance in Table 4.3, Model (1). It shows that alone ICT do not have a positive impact on GROWTH. As the level of technology increases, economic growth declines and these results are consistent with prior studies like Chowdhury (2002), Loveman (1994) and Brynjolfsson (1996).

In Table 4.3, Model (1), We study the marginal and conditional effects of ICT on GROWTH but the indirect effects of information communication technology on economic growth through the channel of human capital can be evaluated by calculating equations (3.1and 3.2) given in chapter 3. The indirect effect of ICT on GROWTH through the channel of human capital for general model is given in Table 4.4. We differentiate the indirect impacts of ICT on growth by categorizing ICT into low level, average level and high level of ICT, whereas, coeffecients, p-values and 95% confidence interval values are given in parenthesis.

Table 4.4 The indirect effect of Information Communication Technology (ICT) on Economic Growth (GROWTH) through the channel of Human Capital (HC)

Channels	**Levels of ICT**	**Indirect Effects**	**95% confidence interval**	
Human Capital	Low Level of ICT	6.53203 (0.000)***	5.1905	7.8735
	Average Level of ICT	6.5407 (0.000)***	5.1978	7.8836
	High Level of ICT	6.5469 (0.000)***	5.2022	7.8909

Note: P-value of each coefficient is given in parentheses. *, ** and *** represents the significance level at 10%, 5% and 1% respectively. Low level means 25th percentile, Average level means 50th percentile and High level means 75th percentile of Information Communication Technology (ICT) respectively.

We observe that the indirect effects of ICT through the channel of HC at low level of ICT is 6.5320, at average level of ICT is 6.5407 and at high level of ICT is 6.5469. The effects at all three levels of ICT are positive and significant at 1% level of significance. The above results suggest that HC does play an important role in defining the effect of ICT on GROWTH in case of 3 years averages data.

We further see that investment (INV) and openness (OPEN) both have significant and positive effect on economic growth (GROWTH) at 1% and 5% respectively. This outcome reveals a positive relationship between investment (INV) and economic growth suggesting that as the level of investment increases it will lead to affect economic growth positively. This result is in consistent with prior studies of (Mankiw et al, 1995) and (Barro and Sala-i-Martin, 1995). Similarly, the positive relationship between OPEN and GRWOTH means that trade openness affects economic growth in such a way that it increases competition and allows for transfer of knowledge and technology (Dollar, 1992).

4.2 Summary

Our estimation results regarding direct, conditional and indirect effects of our different explanatory variables on economic growth (GROWTH) like convergence (YO), investment (INV), openness(OPEN) and human capital (HC) in Tables (4.1 and 4.3) are supporting our research objective and are consistent with prior studies. For instance YO is consistently negative and significant in both models. This result supports the evidence of convergence in our panel study which is consistent with the literature of growth and convergence like Barro (1996), Bleaney and Nishiyama (2000) and Doppelhofer (2000).

On the same basis, we observe that ICT is positive and significant in human capital equation in both models and provides a strong support to our research objectives. Similarly the control variables like openness (OPEN) and investment (INV) are also up to the mark and

provide clear evidence of theoretical background where they affect economic growth positively. As this evidence is provided by Mankiw et al (1995) and Barro and Sala-i-Martin (1995) for investment (INV) and Dollar (1992) for openness (OPEN).

While examining the significance of the indirect effects of ICT at its different levels of economic growth through the channel of human capital (HC). We define our confidence intervals at low, average and high levels of ICT as shown in table (4.2 and 4.4). The indirect effects of ICT on GROWTH are positive and significant at all levels of ICT. These results are supporting our objectives.

We observe that, indirect effects of ICT on economic growth are more profound as compare to the direct effects. The conclusion is based on the coeffecient values of the interaction term of LICTHC. It shows that negative effect of ICT on economic growth (Growth) decreases as the level of human capital increases. In other words, we can say that negative effect of ICT on GROWTH is less profound in countries having high level of HC. Further, to check the feedback effects, we take the first lag of our Core variables, tables are given in Appendix, Table (4.5, 4.6)

Chapter 5

Conclusion and Policy Recommendations

The chapter concludes result of our findings, policy implications, future are of research along with shortcomings of present study

5.1 Conclusions

In our study, we use a panel data set of 44 developing countries to examine the relationship among information communication technology (ICT) and economic growth (GROWTH) through the channel of human capital (HC). We use Seemingly Unrelated Regression (SUR) technique to estimate our econometric model of two equations as suggested by Biorn (2004). We estimate the direct and indirect effects in order to achieve the objectives of the study. Overall, this study explores the direct (marginal), conditional (through interaction term) and indirect effects of information communication technology on economic growth.

Our findings show that information communication technology (ICT) has a negative and significant effect on economic growth in all the models which shows that increase in ICT sector alone do not result in an increase in the output of any economy. Similarly, the interaction term of ICT and HC (LHCICT) is significant and positive in all the models which shows that the conditional effect of ICT on economic growth is positive. In other words, we can say that when human capital increases the negative impact of ICT on GROWTH declines over the time.

Similarly, the effect of human capital on economic growth in all models is positive and significant which shows that if human capital increases in terms of skills, education and trainings it leads to a positive effect on economic growth.

We conclude that there is a direct and negative relationship between ICT and economic growth which shows that an increase in information communication technology tends to

decrease economic growth. Indirect effects of information communication technology on economic growth is a matter of concern, because it is our main objective to explore the indirect effect of information communication technology on economic growth. It is obvious from our results that information communication technology has a positive and significant indirect impact on economic growth. We come with the conclusion that ICT affects human capital positively which further leads to affect economic growth in a positive way. We note that, indirect effect of information communication technology on economic growth is more profound as compared to direct effect.

5.2 Policy Recommendations

Our findings show that indirect effect of ICT on economic growth is significant and positive as compared to direct results. The data is taken from developing countries which includes mostly African countries where use of technology is still scarce. Therefore, government may focus on the policies that initiate research programs in country to make domestic technological progress on one hand and to absorb technological transfer. On the other hand, there is also a need to focus on the policies which provide better facilities to human capital or labor such as better education, trainings and other programs which help them in enhancing their skill so that they can use technological products in a better way and in return it will bring positive impact on growth. In other words, both technology and human capital increase is required to have positive impact on growth as the level of human capital increases the negative impact of ICT will decline over the time.

Likewise, investment (INV) and openness (OPEN) shows positive and significant results so in order to get more profound result of trade openness on economic growth, government should focus on policies which promote healthy trade and reduce the tariffs in order to bring new technologies in country.it also increases competition and provides benefits of large scale economies. Similarly, investment also exerts positive impact on growth. Government should

Invest in production of information communication technology products so that more ICT capital is available to work with, tends to increase labor demand, compels labor to adapt new technologies and skills and in return increase overall productivity.

5.3 Future Research

The present research analyzes the indirect effect of ICT on economic growth in an explanatory manner. As the present study includes developing countries and data on ICT is scarce in these countries so the direct effect ICT on economic growth is negative. In order to overcome this effect, different channels should be explored. While doing future research greater time span and mix of developed and developing countries should be considered.

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APPENDIX

Table A1 Data Description

Variables	Variable name	Definition of variables	Source
GDP growth (annual %)	GROWTH	Log difference of real per capita GDP	Author's construction using WDI(2015)
Inflation	INF	Inflation, consumer prices (annual %)	WDI (2015)
Investment	INV	Gross fixed capital formation (% of GDP)	WDI (2015)
Government expenditure	GOV	General government final consumption expenditure (% of GDP)	WDI (2015)
Log of initial value of real per capita GDP	Yo	GDP per capita (constant 2005 US$)	WDI (2015)
Human Capital	HC	Human capital average years of schooling (0f population with age 15 years and above) as a proxy of human capital	Penn World tables 8.1 (2012)
Openness	OPEN	Trade (% of GDP)	WDI (2015)
Per capita income	PCI	GNI per capita annual %	WDI (2015)
Indicators of Information Communication technology			
Mobile cellular subscriptions	MCS	"Cellular technology that provides access to public switched telephone networks, both postpaid and prepaid"	WDI (2015)
Fixed telephone subscriptions	FTS	"Having access to telephone connections includes active landlines as well as wireless subscriptions"	WDI (2015)
Internet users	IU	"Access to worldwide internet"	WDI (2015)

Table A2. Correlation matrix of information communication technology indicators

	fts	mcs	iu
fts	1.0000		
mcs	0.3507	1.0000	
iu	0.6462	0.7026	1.0000

Table A3 principal component analysis for information communication technology indicators

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.14551	1.4945	0.7152	0.7152
Comp2	.651011	.447533	0.2170	0.9322
Comp3	.203477	.	0.0678	1.0000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Unexplained
fts	0.5311	0.7457	0.4024	0
mcs	0.5552	-0.6650	0.4995	0
iu	0.6401	-0.0418	-0.7671	0

Graph 1. scree plot of Eigen values of information communication technology indicators

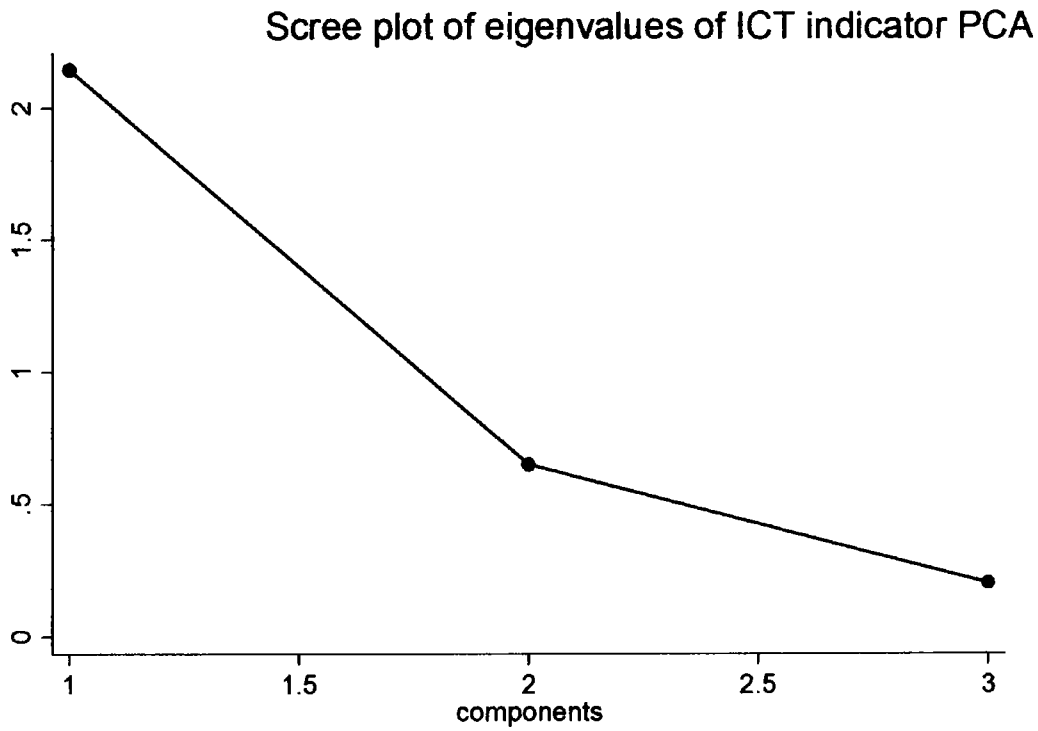

Table A4 Summary statistic

VARIABLES	OBSERVATIONS	MEAN	STD.DEV	MIN	MAX
GROWTH	220	3.083457	2.603483	-3.956199	12.38189
ICT	220	7.983724	1.214532	4.001079	9.605832
HC	220	6.92778	2.578884	1.08	12.05
HCICT	220	15.05039	4.966904	4.001079	23.90954
INV	220	22.34102	5.726018	7.671188	45.51102
Yo	220	2789.413	3197.09	219.5872	22883.83
GOV	220	13.01083	3.942525	4.604715	23.5895
PCI	220	2885.042	3355.459	237.5443	24115.79
OPEN	220	73.28942	34.94214	22.70245	207.7095
INF	220	6.328021	6.238296	.0707527	51.42656

Table A5 Correlation Matrix

	GROWTH	ICT	HC	PCI	INV	GOV	YO	INF	OPEN
GROWTH	1.0000								
ICT	-0.0624	1.0000							
HC	0.1172	0.5592	1.0000						
PCI	-0.0347	0.6086	0.5530	1.0000					
INV	0.4110	0.2726	0.2023	0.2069	1.0000				
GOV	-0.0672	0.2292	0.2615	0.1766	0.0975	1.0000			
YO	-0.0761	0.6125	0.5554	0.9976	0.1886	0.1880	1.0000		
INF	0.0442	-0.1571	-0.0627	-0.0542	-0.1077	-0.1167	-0.0526	1.0000	
OPEN	0.0225	0.2735	0.3605	0.1856	0.0617	0.1273	0.1880	-0.1747	1.0000

Table 4.5 The Effect of information communication technology (ICT) on Economic Growth (GROWTH) through the channel of human capital (HC). (Average one year lag)

VARIABLES	MODEL (1) Parsimonious model		MODEL (2) parsimonious lag Model	
	HC	GROWTH	HC	GROWTH
LICT	0.0451362 (0.000)***	-6.988815 (0.000)***	0.0436829 (0.000)***	-1.395444 (0.000)***
LHC		143.29 (0.000)***		0.101 (0.000)***
LHCICT		0.2103727 (0.066)*		0.2618654 (0.178)
LYo		-29.49975 (0.001)***		-0.000177 (0.02)**
LPCI	0.2006302 (0.000)***		0.1992379 (0.000)***	
LINV		1.703301 (0.000)***		3.388764 (0.000)***
LOPEN		0.794723 (0.044)**		
LGOV				-1.6726 (0.000)***
INF				
Observations	220	220	220	220
No. of Countries	44	44	44	44

Note P-value of each coefficient is given in parentheses. *, ** and *** show the significance level at 10%, 5% and 1% respectively. Our dependent variables are as follows: GROWTH is growth rate of real per capita GDP. LHC represents log of human capital, taken as an average years of schooling (age 15 years and above). Explanatory variables of our model are describes as follows: LICT is log of information communication technology which is constructed using principal component analysis. LYo is log of initial real per capita GDP. LINV is log of gross fixed capital formation as % of GDP. LGOV is log of the general government final consumption expenditures. LHCICT is interaction tern of information communication technology and human capital. LPCI is log of per capita income taken as GNI (gross national income). INF is inflation (CPI).

Table 4.6 The indirect effect of Information Communication Technology (ICT) on Economic Growth (GROWTH) through the channel of Human Capital (HC) Average one year lag

Channels	Levels of ICT	Indirect Effects	95% confidence interval	
Human Capital	Low Level of ICT	0.1744392 (0.000)***	0.1112361	0.2376423
	Average Level of ICT	0.1848556 (0.000)***	0.1166644	0.25304638
	High Level of ICT	0.1923512 (0.000)***	0.1187845	0.2659178

Note: P-value of each coefficient is given in parentheses. *, ** and *** represents the significance level at 10%, 5% and 1% respectively. Low level means 25th percentile, Average level means 50th percentile and High level means 75th percentile of Information Communication Technology (ICT) respectively.

Principal Component Analysis:

Principal component analysis (PCA) was first introduced by Karl Pearson (1901) and was first used by Harlod Hotelling (1930).later on, Hotelling introduces orthogonal decomposition, eigenvalues and factor analysis. It is a unique form of data analysis that is widely used in analysis of all types. It extracts the relevant information from large and complex data sets. In other words, we can conclude that PCA is a technique that reduces noises in the data and uncover the underlying meaning.

Furthermore, PCA uses an orthogonal transformation that converts a large number of correlated variables into linearly uncorrelated variables called as principal components. Principal components that are obtained after analysis are less than or equal to the total number of variables in the data set. Results of PCA shows that the first principal component reflects the largest variance (explains maximum variability in the data set) and after that upcoming components in turn shows high variance and this relation format is followed by the other upcoming components as well.

The model assumption includes that data set must be a linear combination of variables. Direction of the variable(high variance) will not always lead to better discrimination and it is assumed that components having large variance will always give interesting changes in the data set while components with low variance will give description of unwanted changes.

The results of PCA are in terms of component scores called as factor scores and component loadings (correlation between variable and component). Squared loadings are used in which the weights obtained by PCA are multiplied to the variables to get the component scores. PCA is based upon eigenvectors, it allows the researcher to select the eigenvalues that are equal or greater to one. The highest value amongst eigenvalues. It results in a clear picture of a complex and

multidimensional data set. Hence, researcher will focus only on the most important variables and ignores the irrelevant ones. It removes the correlation amongst independent variables that are incorporated in the regression analysis.

Information Communication Technology Index:

Information communication technology (ICT) refers to the variety of goods, applications and services used for producing, distributing and transforming information which includes telecoms, hardware, software and computer services (Marcelle G ,2000). In other words, ICT includes all those products that are related to technology. Kretschmer (2012) explains the term ICT (information communication technology) as information technology (hardware, software), communication (internet, broadband) and telecommunication (mobile phones, landlines).while looking at the literature, we find that there are so many indicators which are overlooked in the previous studies. So to check the impact of ICT we construct a composite measure of ICT by including all possible variables of ICT.

There are various indicators of ICT which includes: personal computers (computers that are designed to be used by a single individual, operated directly by end users), computers communication and other services % of commercial service export and import (it includes those activities such as international telecommunication, postal service etc), household with television (it includes household using their own TV set), broadband subscriptions (it includes subscribers with a digital subscriber line, cable and modem), internet users (access to worldwide internet), international internet bandwidth mbps (international connection between countries regarding internet traffic), secure internet servers (servers using technology in internet transactions), mobile phone subscribers (cellular technology that provides access to public switched networks, both postpaid and prepaid), telephone subscribers (access to telephone connections), telephone mainlines (connect subscribers terminal equipment to public network), telephone employees total (total number of employees working in telephone sector), telecommunication investment (expenditures related ownership of telecommunication), telecommunication revenue (revenue

generated from usage of telecommunication services), and ICT expenditures as a percentage of GDP.

The ICT index is constructed for a group of selected developing countries mostly African countries. The data on various indicators of ICT is scarce in developing countries as the usage of ICT is less in these countries. In order to construct ICT index, only those indicators are used which shows full availability of data for developing countries that are FTS (fixed telephone subscriptions), MCS (mobile cellular subscriptions and IU (internet users). Principal Component Analysis is used for the construction of ICT index. The detail of ICT index is available in Appendix. The lowest point of ICT index is 0 which indicates minimum usage of ICT in the respected country whereas the highest point that is given to ICT index is 8 which indicates the maximum usage of ICT in the particular country.

SUR Model as Suggested by Biorn (2004):

SUR model ignores time invariant effects and it resolve endogeneity problem. Also it considers dependent variables to be endogenous. In SUR model error terms are uncorrelated over the time but in cross equations error terms are correlated. Sur model contains various regression equations where every equation has its own dependent variable. This model is named as seemingly unrelated because each equation is estimated separately and a valid linear regression. SUR model is basically the simplified form of GLS (general linear regression model).

In order to estimate our model equations by using SUR model, we use XTSUR command that is introduced by Nguyan (2010). XTSUR command consist of multistep logarithm which is the combination of ML (Maximum Likelihood) and GLS (Generalized Least Square).Observations in the panel data are observed 1…t times in XTSUR command. The values once observed by XTSUR come first, the values which are calculated twice comes second and the values calculated thrice comes at third and so on. One of the advantage of XTSUR command is that it rearranges the unbalanced panel data into balanced panel data and every observation is observed according to the number of iterations.

Further by using the XTSUR, estimators of SUR model can be obtained by the MML (Multistep Maximum Likelihood) method which allows the estimators of the model to converge.

Moderated Mediation Analysis:

In our analysis we use Moderated Mediation approach that is presented by Preacher et al (2007) and Muller et al (2005).The statistical models in which moderation and mediation comes together are known as moderated mediation analysis. Conditional Indirect effects are also termed as Moderated Mediation analysis.

Moderation occurs where the relationship among two variables (independent and dependent variables) is based on third variable is known as Moderator. In statistics, the effect of interaction term is shown by moderator or by conditional effects. Interaction occurs between two or three variables where the magnitude of relationship of third (dependent variable) depends upon the magnitude of interaction term.

For example $y = \gamma_0 + \gamma_1 X_1 + \gamma_2 X_2 + \gamma_3 (X_1 . X_2) + \varepsilon$

Where $(X_1 . X_2)$ is an interaction term which indicates conditional effect.

Mediation analysis represents the indirect effect which occurs when the relationship of dependent and independent variable is observed with the inclusion of third variable. In mediation, independent variable effects mediator which in turn effects dependent variable.

Independent variable ⟶ Mediator variables ⟶ dependent variable

Indirect effects always gives good understanding of the magnitude of relationship as compare to direct effect of dependent and independent variable.

Solow paradox or computer paradox:

During 1970 and 1980's US economy invested heavily in the IT (information technology) sector but it results in reduction of growth. The Solow or computer paradox becomes popular. Robert Solow (1987) states that "you can see computer age everywhere but in the productivity statistics". After that, a gap between IT investments and output from IT investment arises. Although the numeric shows a hundred fold increase in US productivity. There are several reasons of this Pandora. Brynjolfsson (1993), discuss different reasons of this paradox mainly: wrong computation of input and output, difference between learning and adjustment of new technology, Re-distribution of revenue, mismanagement policies of IT (information technology) and assumptions that allows to adapt new technology without knowing it.

Another reason of this paradox is lack of skills because human capital needs time to adjust with the new technology. When firms are implementing new technologies and level of human skill remains the same, it will not lead to productivity gains from the given technology. In order to attain better results from new technology improved skills are required.