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HUMAN CAPITAL, TECHNOLOGY AND ECONOMIC GROWTH IN INDIA: AN ARDL APPROACH

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Abstract

Growth and development of an economy is the main focus of economists as well as policy makers of any country. Traditional growth theories concentrates on capital used in their production functions. However, endogenous growth theories emphasizes on human capital and technology are important for growth of an economy. In the literature, there exists several studies to verify the impact of human capital on economic growth, but the empirical evidence is not uniform across the countries. In this context, this study wants to examine the long run relationship between human capital, technology and economic growth of India for the period 1991 to 2015. Here, we used an ARDL bound test approach to test this relationship.

Key words: Economic growth, human capital, technology, endogenous growth model, ARDL.

I. INTRODUCTION

Economic growth and development is the major objective of any country or a society. Economists usually measure economic growth in terms of gross domestic product (GDP) or related indicators such as gross national product (GNP), per capita gross domestic product etc. A wide range of phenomena ranging from indicators of "quality of life" to "human development," the increase in per-capita GDP is a major component of economic and social development. The observed pattern in economic growth across countries and time is different. For the last several decades it has become the motivating factor for economists is to investigate the sources of long-run economic growth and development as some countries has prospered and some others did not. It was revealed by statistical analysis of group of nations that the countries with the highest GDP per capita are observed to be the most developed nations. (See Easterly 2002).

It is evident from the literature of the modern growth theories is that one of the major determinants of economic growth process is human capital. Sustainable and inclusive growth couldn't be achieved without major contribution of skills, knowledge or value of people, commonly known as human capital. One of the most influential economists of recent times Lucas (1988) argues that the accumulation of human capital is responsible for sustained growth, and education is the main channel through which the human capital accumulates. Also Romer (1986, 1990) show that human capital, which generates innovations, stimulate growth. So, it is widely accepted that human capital can be considered as one of the main determinants of economic growth (see Mankiw et al, 1992; Barro, 2001). Furthermore, some argued that economic growth could lead to human capital accumulation see for example Mincer (1996). So, the empirical research did not show any clear causal relationship between economic growth and education .

Moreover, the empirical studies in this area of research have found different results with regard to establishing the relation between education and economic growth. For example, Lee (2005) found the strong relationship between physical, human capital and economic growth for Korea. John Whalley(2010) observed that human capital plays an important role in China's economic growth. Number of studies conducted on human capital and economic growth in Nigeria also revealed positive.(e.g.,Sankay et.al, (2010),Adawo(2011), Adelakun(2011), Kanayo(2013), and Chindo Sulaiman(2015)). In some other studies, Levine and Renelt (1992) show that education does not have significant impact in many of the growth regressions they have estimated. Bils and Klenow (2000) finds the weak causality from education to growth. Benhabib and Pritchett (1997) report fragile correlation between growth and education.

One of the early studies on role of technology and human capital can be attributed to Nelson and Phelps (1966). They studied the relationship between structures of capital technological progress. Their findings revealed that in countries which are technologically advanced, the returns to education are higher. Romer (1990) modeled long run economic growth on research and development (R&D) and observed that when firms are involved in R&D, it results in technological change and enhances total factor productivity (TFP) which becomes the immediate cause of economic growth. Many studies identified technology also one of key factors for economic growth (see Romer, (1990); Aghion and Howitt, (1998)).

More recently, several studies have been conducted for a group of countries in addition to country specific studies. Vinod H D (2007) used time series and panel models for eighteen developing countries and identified that human capital is a major determinant for growth. Dulleck and Foster (2008) has studied the impact of human capital on economic growth for a set of developing countries and found that there is a negative relationship between human capital and economic growth for the countries with a low level of human capital, while the high relation in countries with the highest level of human capital. Contrarily, Zaman (2012) indicated a weak relationship between human capital and economic growth for 100 countries using the panel data estimation technique. Mohsen Mehrara, et.al (2013) examined the causality between human capital and economic growth for the group of developing countries over the period 1970-2010. These results showed that it was the investment and GDP that was driving human capital in those countries, not vice versa.. Using the Panel data for the developing countries Elena Pelinescu (2015) showed that human capital is a crucial factor of the growth.

But a very few studies have been conducted in India to see the relationship between human capital, technology and economic growth. Haldar S K and Mallik G (2010) found that the investment in education and health are very important and has a significant positive long run effect on per capita GNP growth. Maksymenko S and Rabbani M (2011) has observed that the human capital accumulation produce a significant long-run effect on economic growth. Benerjee and Roy (2014) conducted a study to identify the determinants for India's growth in the long-run and found that human capital, technological progress and trade were the major determinants of growth. They have applied growth accounting framework and ARDL-based cointegration technique to identify the factors that drive long-run growth. The rest of the paper is organized as follows. Section 2 describes the data, variables and methodology used in this study. In section 3 we present the empirical results and in section 4 we give summary and conclusions.

II. OBJECTIVES OF THE STUDY

The main objectives of this study are to identify relationship between human capital, technology and economic growth in the long run as well as short run by using the ARDL approach in India for the period 1991 - 2015.

III. DATA, VARIABLES AND METHODOLOGY

In this section we describe the data, variables and econometric methodologies used in this study.

3.1 Data and variables:

This study uses annual series for the period of 1991 to 2015 and all the data is obtained from World Development Indicators (WDI). The growth rate of real per capita (GPCGR) was used as proxy for economic growth, secondary school enrollment was used as proxy for human capital (HC), labor force (LAB) was used to proxy for labor, total factor productivity (TFP) was used as proxy for technology and gross fixed capital formation(CAP) was used for physical capital.

3.2 Model Specification:

In this study we have used the extended model of human capital theory advocated by Romer (1990). The human capital theory states that growth is influenced by not only labor and capital but also human capital. As recent theoretical as well as empirical studies showed that technology is also one of the influential factors for growth of an economy. (See Romer (1990),Barro (1991), Mankiw, Romer and Weil(1992), Aghion and Howitt, (1998)),Alani (2012)). Following the new evidence we extended the Romer model by introducing the technology as one of the exogenous variables along with labor, physical and human capital. Hence, the growth function is considered in this paper as follows:

$$LNGPCGR = f(LNLAB, LNCAP, LNTFP, LNHC) \tag{2.1}$$

3.3 Methodology

The ARDL bounds testing approach has been employed here to examine the relationship between the dependent variable per capita growth rate (GPCGR) and explanatory variables (LAB, CAP, TFP and NHC). The ARDL model was introduced by Pesaran and Shin (1999) and further extended by Pesaran, Shin and Smith (2001). This approach is based on the estimation of an Unrestricted Error Correction Model (UECM) which enjoys several advantages over the conventional type of cointegration techniques, such as Johansen and Juselius (1990) cointegration tests. First, it can be applied to a small sample size (Pesaran et al. (2001)) and therefore conducting bounds test will be appropriate for the present study. Second, even in the presence of omitting variables and autocorrelation problems which are very common in time series analysis, we can estimate the short- and long-run components of the model simultaneously. Third, the standard Wald or F-statistics used in the bounds test has a non-standard distribution under the null-hypothesis of no-cointegration relationship between the examined variables, irrespective whether the underlying variables are I(0), I(1) or fractionally

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integrated. Once, the orders of the lags in the ARDL model have been appropriately selected, we can estimate the cointegration relationship using a simple ordinary least square (OLS) method.

In view of the above advantages, ARDL-UECM used in the present study has the following form as expressed in Equation ():

$$\Delta LNGPCGR_t = \beta_0 + \sum_{i=1}^{p} \delta_1 \Delta LNLAB_{t-i} + \sum_{i=1}^{p} \delta_2 \Delta LNCAP_{t-i} + \sum_{i=1}^{p} \delta_3 \Delta LNTFP_{t-i} + \sum_{i=1}^{p} \delta_4 \Delta LNHC_{t-i} + \sum_{i=1}^{p} \delta_5 \Delta LNGPCGR_{t-i} + \beta_1 LNGPCGR_{t-i} + \beta_2 LNLAB_{t-i} + \beta_3 LNCAP_{t-i} + \beta_4 LNTFP_{t-i} + \beta_5 LNHC_{t-i} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots \quad (2.2)$$

Where, GPCGR represents GDP per capita growth rate of India. LAB is the growth rate of labor force in India. CAP represents the gross fixed capital formation to GDP. TFP is taken as a proxy variable for technology and secondary school enrollment is taken as proxy variable to denote human capital.

The first step in the ARDL bounds testing approach is to examine Equation (2.2) by ordinary least squares in order to test for existence of a long-run relationship among the variables by conducting an F-test for the joint significance of the coefficients of the lagged level variables, that is, $H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ against the alternative$H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$. Two sets of critical value bounds for the F-statistic are generated by Pesaran et al. (2001). If the computed F-statistic falls below the lower bound critical values, the null hypothesis of no-cointegration cannot be rejected. Contrary, if the computed F-statistic lies above the upper bound critical value; the null hypothesis is rejected, implying that there is a long-run relationship amongst the variables in the model. Nevertheless, if the calculated value falls within the bounds, inference is inconclusive.

In the second step, once cointegration is established, the conditional ARDL long-run model for $GPCGR_t$ can be estimated as shown in the Equation (2.3):

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$$\Delta LNGPCGR_t = \beta_0 + \sum_{i=1}^{p} \delta_1 \Delta LNLAB_{t-i} + \sum_{i=1}^{p} \delta_2 \Delta LNCAP_{t-i} + \sum_{i=1}^{p} \delta_3 \Delta LNTFP_{t-i} + \sum_{i=1}^{p} \delta_4 \Delta LNHC_{t-i} + \sum_{i=1}^{p} \delta_5 \Delta LNGPCGR_{t-i} + \varepsilon_t \ldots\ldots\ldots (2.3)$$

This involves selecting the orders of the ARDL (p,q) model using Akaike information criterion (AIC). In the third and final step, we obtain the short-run dynamic parameters by estimating an error correction model associated with the long-run estimates. This is specified as follows:

$$\Delta LNGPCGR_t = \beta_0 + \sum_{i=1}^{p} \delta_1 \Delta LNLAB_{t-i} + \sum_{i=1}^{p} \delta_2 \Delta LNCAP_{t-i} + \sum_{i=1}^{p} \delta_3 \Delta LNTFP_{t-i} + \sum_{i=1}^{p} \delta_4 \Delta LNHC_{t-i} + \sum_{i=1}^{p} \delta_5 \Delta LNGPCGR_{t-i} + \emptyset ECM_{t-1} + \varepsilon_t \ldots\ldots (2.4)$$

Where, $\delta_1, \delta_2, \delta_3, \delta_4$ and δ_5 are the short-run dynamic coefficients of the model's convergence to equilibrium and $\emptyset$ is the speed of adjustment parameter and ECM is the error correction term that is derived from the estimated equilibrium relationship of Equation (2.2).

IV. EMPIRICAL ANALYSIS

In this section we present the empirical findings of this study.

4.1 Results of Unit Root Test:

It is essential to test for unit roots of the variables as any time series analysis that the variables should be stationary for valid inferences. Here, we have employed Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests to check for the unit root in each variable there by to determine the order of integration. The results of unit root test are presented in the Table 3.1. The results confirm that LNGPCGR is stationary at levels and they are integrated of order I (0), while LNLAB, LNCAP, LNTFP and LNHC are stationary at first difference i.e. I (1). Since the variables are either I (0) or I (1), the ARDL procedure is more appropriate for the analysis.

Table 4.1 the Results of ADF and PP Tests

	Levels		First Difference		
Variables	ADF	PP	ADF	PP	Inference
LNGPCGR	-4.337668*	-4.343292*	--	--	I(0)

LNLAB	-1.095880	-1.366390	-4.085938*	-4.097915*	I(1)
LNCAP	-1.909982	-1.909982	-4.947506*	-4.963828*	I(1)
LNTFP	-1.273527	-1.695424	-3.745476**	-3.745476**	I(1)
LNHC	-1.54494	-1.730986	-4. 179366*	-4.179366*	I(1)

Notes: *,**,*** indicates significance at the 1%,5%,10% level respectively.

4.2 Bounds F-test for Cointegration

In table 3. 2 we provide the result of ARDL bounds F-test for cointegration relationship based on equation (2.2). The appropriate lag length was selected on the basis of AIC for the conditional ARDL-UECM. These results shows that the computed F-statistic is greater than the upper bound critical value of 3.49 at the 5% significant level. Thus, the null hypothesis of no cointegration is rejected, which indicates there is a long-run cointegration relationship among economic growth and independent variables chosen in this study.

Table 4. 2 Results of Bounds Test for Cointegration

	Critical Value	
Computed F-Statistic: 4.145**	Lower Bound	Upper Bound
1% significance level	3.29	4.37
5% significance level	2.56	3.49
10% significance level	2.2	3.09

Notes: ** indicates that computed statistic falls above the upper bounds value at 5% significance level. The bounds critical values are obtained from Pesaran et al. (2001)

4.3 Long-run Estimates of ARDL Process

Once the existence of cointegration relationship among the variables is established, equation (2.3) is estimated for the long-run coefficients of the selected ARDL model based on the AIC and its results are presented in the Table 4.3.

Table 4.3 The Estimated Long-run Coefficients Based on Akaike Information Criterion

Variable	Coefficient	t-statistic	Prob. Value
Constant	9.333173	1.501920	0.1553
LNLAB	0.211978	2.864603**	0.0125
LNCAP	2.326841	2.369011**	0.0328
LNTFP	2.488657	1.989588***	0.0665
LNHC	3.234021	2.657829**	0.0187

Notes: *, **, *** indicates significance at the 1%, 5%, 10% level respectively.

From table 3.3 we can see that the human capital has significant positive impact on economic growth. This implies that an increase in human capital would lead to an increase in economic growth, which is in accordance with the theoretical belief. The variable technology also shows a positive and significant effect at 10% level of significance. The technology is believed to have a direct positive impact on growth because technology helps in speeding up the production process, increase in labor productivity improves the quality of products being produced. All these processes at the end contribute to increasing growth. The labor and capital in the model have also been found to be significant and have a positive significant impact on growth.

4.4 **The Estimated Short-run Coefficients**

The results of short-run dynamic coefficients associated with the long-run relationships obtained from the ARDL-ECM Equation (2.4) are presented in Table 3.4. These results show that estimated error correction coefficient is negative and significant at 1% level, ensuring the disequilibrium in the dependent variable from the previous period's shock converges back to the long-run equilibrium in the current period. This also supports the notion of technology improves growth even in the short-run. Other variables in the model, labor and capital, are found to be significant which is in agreement with the theory. The coefficient of human capital is positive and significant which implies that an increase in human improves growth in the short-run.

Table 4.4 Error Correction Representation

Variable	Coefficient	t-statistic	Prob. Value
D(LNLAB)	0.358593	2.997012**	0.0096
D(LNCAP)	2.682626	2.178603**	0.0469
D(LNTFP)	4.508517	1.848183***	0.0858
D(LNTFP(-1))	9.580741	3.490025*	0.0036
D(LNHC)	5.363357	3.687660*	0.0024
ECT(-1)	-1.360703	-6.677252*	0.0000

Notes: *, **, *** indicates significance at the 1%,5%,10% level respectively.

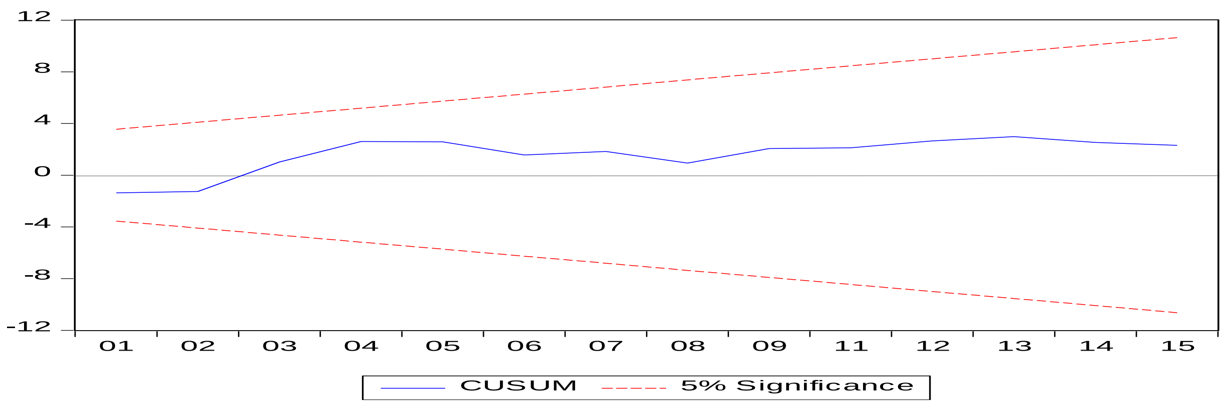
Table 4.5 Short-run Diagnostic Tests

Serial Correlation LM Test (χ^2)	0.6756 (0.32)
Heteroscedasticity Test (χ^2)	1.14 (0.33)

4.5 Stability of the ARDL Process

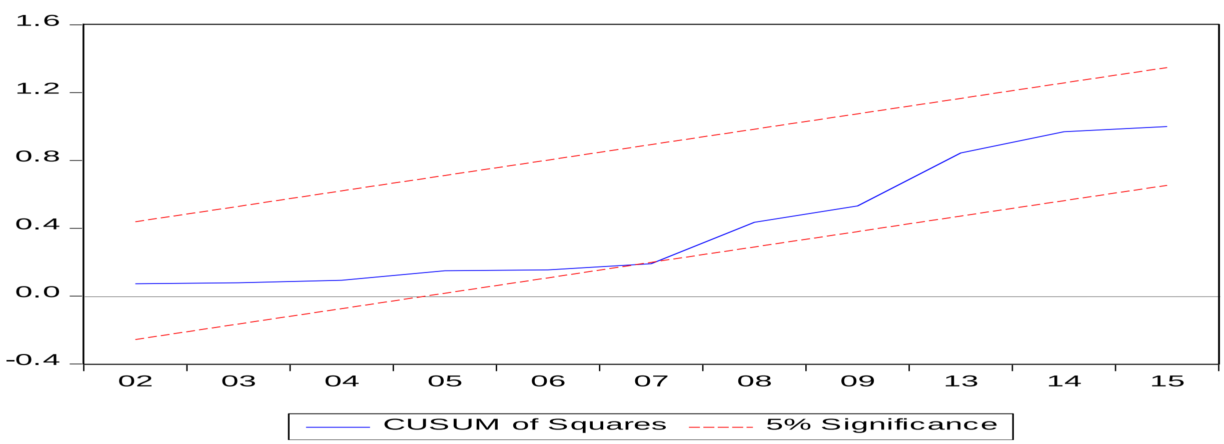
To see the short-run dynamics we have used diagnostic tests, viz. Breusch – Godfrey Serial Correlation LM test, Autoregressive Conditional Heteroskedasticity (ARCH) test to examine the validity and reliability of the short-run ARDL – ECM model. and these results are shown in Table 3.5. The results indicate that short-run model passes through all diagnostic tests and there is no evidence of autocorrelation in the disturbance of the error term. The ARCH tests suggest that the errors are homoscedastic. Also we examine the stability of the long-run coefficients together with these short-run dynamics by applying the Cumulative Sum of Recursive Residuals (CUSUM) and Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) plots. The CUSUM and CUSUMSQ plots for the estimated model are shown in Figures 3.1 and 3.2. If the plots of the CUSUM and CUSUMSQ statistics stay within the critical bounds at the desired level of significance, the null hypothesis of all coefficients in the given regression are stable and cannot be rejected.

Figure 4.1 Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure 4.2 Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

From the Figures 3.1 and 3.2 we can see that CUSUM and CUSUMSQ statistics are well within the 5% critical bounds implying that short-run and long-run coefficients in the ARDL –Error Correction Model are stable.

V. SUMMARY AND CONCLUSIONS

Economic growth is the prime concern of all the countries to raise the standard of living of the people. The main focus of this study is to investigate the impact of human capital, technology, labor force and physical capital on economic growth in India over the period of 1991 to 2015 using annual data. From the unit root test we observed that the variables considered in this study are having different order of integration. So, the ARDL approach to cointegration has been applied to examine the long run relationship. The results of the long-run and short-run models reveal that human capital, technology, labor and physical capital showing positive significant impact on the economic growth in India. The error correction term in this model has confirmed the speed of adjustment of the variables convergence to equilibrium in the long run. It is also confirmed diagnostic tests such as Breusch – Godfrey Serial Correlation LM test, Autoregressive Conditional Heteroskedasticity (ARCH) test and the stability tests of CUSUM and CUSUMSQ. The study finds that the human capital, technology, physical capital and labor are not only theoretically growth-driven variables but also empirically growth driven variables.

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