Factor Accumulation and Economic Growth in Pakistan: Incorporating Human Capital

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Abstract

The objective of this study is to analyze relationship between factor accumulation and economic growth in Pakistan for the time period of 1973 to 2014 using ARDL bound testing approach to cointegration. Considering human capital as a core factor of production we have constructed a series of human capital as average year of schooling and real capital stock is also generated on the basis of gross fixed capital formation. Under endogenous growth model bound testing approach to cointegration suggest that human capital stock, real physical capital stock per worker and GDP per worker are highly cointegrated. Moreover, human capital and real physical capital stock are highly significant and growth friendly. Our findings are consistent with the endogenous growth model suggesting that developing countries like Pakistan should increase share of education and health in GDP in order to accelerate economic growth.

Keywords: Growth, Factor Accumulation, Capital Stock, Human Capital, ARDL, Pakistan

1. Introduction

Sources of long run economic growth in developed and developing countries are the most debated question in the literature. There are two sources of economic growth, either productivity growth or factor accumulation (physical capital, employed labor force and human capital). However, there are three strands in the literature, first who supported the view that, it is productivity growth that caused economic growth (Chow, 1993; Hu & Khan, 1997; Iwata et.al. 2003; Nachega & Fontaine, 2006). Second who supported the other view that economic growth is caused by factor accumulation (Krugman, 1994; Beddies, 1999; Young, 2000; Iwata et.al. 2003; Nachega & Fontaine, 2006). Third who consider human capital as an important source of economic growth (Lucas, 1988; Romer, 1986; Beddies, 1999; Haldar & Malik, 2010). Chow (1993), Hu and Khan (1997) and Iwata et al. (2003) did not consider human capital as an input factor in their research. Efficiency of human capital determines level of economic growth (Zeng, 1997). Growth of total factor productivity (TFP) and human capital are necessary to boost economic growth (Wang & Yao, 2003).

Smith (1776) said that growth actually depends on division of labor force but he did not give a clear link between them. The concept of economic growth starts with Solow (1956) growth model. Solow (1956) highlighted the idea that economic growth cannot be explained by increasing labor and capital only but it was technical progress that contributes to economic growth along with labor and capital. Solow (1956) growth model was considered as central framework of economic growth. A number of researchers highlighted the importance of human capital in past few decades such as endogenous growth theory which was presented by Lucas (1988) and Romer (1990). They found human capital a primary source of economic growth. Moreover, it is evident that human capital successfully attracts other factors of production like physical capital. Lucas (1988) considered education and training as a measure of human capital. Development of human capital is the sole purpose of education to attain economic growth. Lucas (1988) and Romer (1990) suggested that a country should invest more on human capital because it can contribute to economic growth and social welfare. It has purely positive link with labor productivity and will result into high wages and high expected lifetime returns. Later on, Fogel (1994) highlighted the point that education and training with good health, strong physical and mental capabilities can enhance the production of human capital or labor force. Seren and Marti

(2013) suggest that in developing countries like Pakistan (where tax payers avoid taxes) with low nominal tax rate human capital did not contribute to economic growth but inversely.

In spite of the importance of human capital, still the most debated question is what are the key indicators which are considered as human capital? What should be the most appropriate proxies for human capital? These proxies are varying across researcher to researcher but they all focused on either mixture of education and health or separately to measure human capital. In the earlier literature, literacy rate is used by Romer (1990), to capture the impact of human capital and he found that it had positive link with growth. Mankiw, Romer, and Weil (1992) prefer enrollment in secondary school to measure human capital and they conclude that human capital can boost up the economy. Khan (2005) conducted a single country analysis by using gross secondary school enrollment, average years of schooling, and life expectancy as an indicator of human capital. Some studies used education and health expenditure to capture stock of human capital but all these proxies did not reflect true picture of available human capital stock. Conceptually, all these proxies were unable to measure the available stock of human capital adequately. Barro and Lee (1993) developed a proxy (educational attainment) for available human capital stock for 73 countries by using enrollment at different level of education. Wang and Yao (2003) used the same methodology but with different flow variables to develop a series for available stock of human capital in China.

Almost every developing country is suffering from two major issues; first how to attain economic growth and second how to sustain economic growth. Sustaining high growth rate is more difficult in developing countries. Pakistan economy was growing around 5% per year till 2008 but after that government was unable to sustain this growth rate due to failure of various policies including political instability. Growth rate was 8% in 2004-05 which was the highest level but now the million worth question is what government should do to catch that high level of growth and to sustain it? Many researchers in Pakistan focus on the importance of human capital by using different proxies to find its link with the economic growth. Abbas (2000) used enrollment at different level of education (i.e. primary, secondary and higher) as a stock of human capital (in comparative analysis between India and Pakistan) to analyze its effect on economic growth. He found that these proxies have positive impact on economic growth. Khan (2005) analyzed four different measure to capture stock of human capital i.e. literacy rates,

average years of schooling, gross secondary school enrollment, and life expectancy. His finding supports the view of Fogel (1994) that high education and strong physical and mental health will result in a more productive work force, these active participants can increase total factor productivity, and help the country's production function to move outward. Ali et al. (2012) used traditional inputs incorporating human capital as education enrollment and expenditure on health under ordinary least square technique they concluded that human capital contribute to economic growth significantly. Qadri and Waheed (2014) developed a new series for human capital by using primary enrolment ratio and health indicator (expenditure on health) and conclude that this series is comparatively a better series than previously used, because earlier studies used health or education indicators separately in their analysis.

With reference to above literature there is a gap in the literature in context of relationship between factor accumulation and GDP per worker in Pakistan. Although this question is addressed in previous studies but no one address issues regarding the measure of human capital. They used directly measureable proxies (traditional measures) to measure human capital which do not reflect the true picture of human capital stock. Moreover, none of the researcher constructed series for human capital to capture available stock of human capital and real physical capital stock. Using direct measure is technically incorrect as they do not reflect the true stock of real physical capital stock and human capital stock. It is observed that initial studies used education as a measure of human capital in both cross country analysis and single country analysis. Recently, studies are focusing on education, training and health all together to measure human capital stock.

This study focuses on long run relationship between factor accumulation and economic growth under endogenous growth theory and ARDL framework for the time period 1973 to 2014 in Pakistan. Specific objectives of this study are: to develop a series for human capital to calculate stock of human capital, to develop a series for capital stock to calculate stock of real physical capital, to investigate the relationship between factor accumulation and economic growth.

This study challenges the notion of human capital. Conceptually, earlier proxies of human capital used by different researcher did not reflect the exact picture of the human capital stock in Pakistan. This study develops a human capital index for Pakistan by following the methodology

of Wang and Yao (2003) and generates a series for human capital in Pakistan. The series for real capital is also generated unlike the previous studies that used gross fixed capital formation or gross domestic investment as proxy for physical capital stock. Results of the study may help the policy makers to design appropriate policies by considering human capital a growth accelerating factor.

2. Literature Review

Solow (1956) stated that economic growth is exogenously determined by technological progress. He emphasized on technological factor rather than human capital. The term human capital comes from the earlier work of Mincer (1958) and later in a study conducted by Schultz (1961). They highlighted the point that Solow (1956) ignored an important factor of production, which is human capital like other factor of production (physical capital and labor force). In their earlier work they conclude that investing on human capital can accelerate economic growth. Term 'Investing on human capital' means that investing on education, health and on training which ultimately generates active participant of production process. Active participants are more productive factor of productions that will increase productivity which will cause economic growth. Later on, endogenous growth theory again highlighted this point that human capital is the prime factor that significantly cause economic growth Lucas (1986), Romer (1988, 1990) and Rebelo (1991). However, measurement of human capital was not addressed properly in the literature. To address this issue various researcher used various measures for human capital (i.e. enrollments of various level of education, average years of schooling, share of education in GDP, literacy rate and all these measures end up with the conclusion that human capital is a primary source in growth process. There are two strands about the measure of human capital. First, macro economists consider education as measure of human capital. Second, micro economists measure human capital in terms of health because physically healthy worker is more active and productive. We can conclude that education and health are primarily measures of human capital.

During the last three decades, researcher focus on relationship of human capital formation and economic growth. Different studies empirically documented strong association between factor accumulation and GDP. Schultz (1961) and Becker (1962) analyzed augmented growth model with human capital and conclude that human capital plays significant role in growth process.

Prior cross country studies, come up with the direct and significant link among human capital and GDP by considering enrollment ratio at different levels (Lucas, 1986; Romer, 1988; Barro, 1991; Kyriacou, 1991). Rosenzweig (1990) point out that growth in human capital is higher in developed countries than developing countries which lead to the differences in standard of living.

Mankiw et al. (1992) analyzed whether Solow growth model is consistent with the growth variation. They used panel data for 121 countries from 1960 to 1985 and traditional inputs incorporating human capital. They used OLS and their findings were strongly in favor of endogenous growth theory that human capital (adult population enrolled in secondary level between ages 12-17) is the primary source of economic development. Endogenous growth model explained 80% variations in income in different countries under consideration. Hu et al. (1997) investigated the sources of economic growth of China from 1952 to 1994 under growth accounting framework. They used Solow growth model with GDP, physical capital, labor force and productivity growth. They regress GDP on other variables under consideration and conclude that productivity growth contribute 40% to economic growth whereas physical capital is also a determinant of economic growth. Bils and Klenow (2000) analyzed the cointegration among human capital and growth. They considered high enrollment rate in schools as human capital and found that high enrollment rate in education can speed up the level of productivity and which will increase economic growth. They concluded that increasing the share of education in GDP will accelerate the productivity and GDP in the long run.

Abbas (2000, 2001) examined the impact of human capital on GDP (proxy for economic growth) in a cross country analysis - Pakistan and India (2000) and Pakistan and Sri Lanka (2001). He used standard growth accounting framework and endogenous growth theory. His findings support the endogenous growth theory that human capital played a significant role in the development of middle income countries. He concluded that high enrollment at different level of education (primary, secondary and higher) can produce more productive workforce by attaining knowledge and training. Seren et al. (2002) examined the relationship between human capital and GDP and effect of the level of income on human capital accumulation. Their analysis was on Spanish regions for the time period 1964 to 1999. They come up with the conclusion that human capital and growth of income are positively and significantly linked together, moreover increasing human capita can increase and sustain economic growth.

Xiaoqing (2005) examine the relationship between share of GDP on physical capital and GDP. He used time series data from 1972 to 2002 and total investment in physical capital and health is taken into account other than traditional inputs as explanatory variables. He found that investment in physical capital and investment in health contribute to GDP of China for the selected time period. He concluded that a country should increase health and investment budget to put the country on the growth track. Mamuneas et al. (2006) analyzed the contribution of traditional inputs incorporating human capital in process of growth. They used panel data for 51 countries from 1971 to 1987. Under endogenous growth model and semi parametric methodology they used GDP as dependent variable and augmented human capital (augmented labor), capital stock, total factor productivity and technological change as explanatory variables. They conclude that in 12 high-income economies, the returns on human capital are equal, whereas the private return on human capital exceeds. Five low income economies shows same situation, while 14 out of the 16 middle income economies, return on human capital were less than the private rate of return on human capital.

Sequeira (2007) analyze the impact of human capital in research and development (R&D) activities. He used several measures of human capital i.e. composition of education into high tech and low tech education from 1970 to 2000. The study assumed that main inputs of research and development labs are scientist and engineer. He used standard increasing variety growth model, system equation approach and 2SLS estimation technique for the analysis and conclude that high tech human capital affects significantly and positively to R&D activities and accelerate growth. Haldar and Malik (2010) examine the impact of share of real physical capital and human capital stock on GNP (economic growth) under co-integration framework. They used time series data of India from 1960 to 2006 and used sum of share of education and health in GNP as proxy of human capital. Whereas, taking per capita GNP as dependent variable, education expenditure, health expenditure, infant survival rate, and life expectancy at birth and primary enrolment rate are the other variables of interest. Autoregressive distributed lag (ARDL) approach to co-integration is used which could not come up with the evidence of co-integration among the variables (physical capital and per capita GNP) whereas the human capital per capita GNP are co-integrated.

Galor et al. (2010) aimed to develop a new model to observe changes in endogenous model by replacing physical capital with human capital. They considered human capital as prime factor of production which can sufficiently accelerate GDP of a country. They took output produced as dependent variable, and capital stock, human capital stock and technology shock as explanatory variables in the analysis. The conclusion of this study is consistent with the endogenous growth model that human capital is more important than physical capital for the growth of countries. Bottone et al. (2011) estimate the extent under which a better institution affect worker force productivity by addressing measure of human capital. They used panel data from 1996 to 2006 of 11 European countries. They used some new measures of human capital (i.e. education, work experience & training) and governance indicator proxy for quality of institution, proxy for quality of worker force is percentage of working age population. Results of this study conclude that institutions affect the quality of labor force and individual will get additional knowledge when this additional knowledge will let him to improve his social life where he lives.

Ali et al. (2012) analyze the effect of human capital formation on GDP. He used time series data of Pakistan from 1972 to 2011 with traditional inputs including human capital (proxy by education enrollment and health measure) and physical capital, investment growth rate as independent variables while GDP is dependent variable. Using OLS they conclude that human capital and physical capital have positive influence on GDP, whereas on the other hand growth rate of investment was not found growth friendly. Asma et.al (2012) investigated the link between human capital and GDP and used time series data for Pakistan from 1974 to 2009. They used two proxies for human capital individually i.e. health and education. Johansen co-integration technique is used for co-integration and long run and short run parameters are estimated by VECM specification. They found that both the proxies of human capital are co-integrated with the GDP and conclude that although Pakistan is spending less on education and health but still it is growth friendly for Pakistan.

Gitto et al. (2013) aimed to observe the relationship between changes in labor productivity and factor accumulation including technological advancement. They used panel data for different regions of Italy from 1980 to 2006. They reveal several conclusion i.e. difference in the accumulation of capital stock in Italian regions is the primary reason for the difference in the growth of the region, human capital comes out to be growth friendly in the Italian regions under

consideration, high income region have more technological progress. Savy et al. (2013) investigated the contribution of human capital in growth process for 22 African countries from 1970 to 2000. The study divided the time period from 1970 to 2000 period into six intervals. They followed neoclassical growth model developed by Islam (1995) as the basic framework. They conclude that decreasing return to human capital generate a positive and significant impact on GDP of African countries. Qadri and Waheed (2014) aimed to examine the impact of human capital on economic development. They used time series data for Pakistan from 1978 to 2007 and GDP as dependent variable, whereas, gross domestic investment (capital stock), labor force or employment (labor input) and human capital (developed by adjusting health expenditure and primary level enrollment) as explanatory variables. They found that proxy for human capital highly co-integrated and significant influencing economic growth positively.

After reviewing the theoretical and empirical literature, we can observe that in both cases, single country analysis or cross country analysis all the studies are consistent with the endogenous growth theory that human capital plays an important part in growth process. While all the studies used several measures to capture human capital and found positive link with the GDP of the country. Initial literature on human capital (endogenous growth theory) used education enrollment ratio, some other education related measure to calculate human capital in both cross country analysis and single country analysis. But over time studies start to focus on education incorporating health to reflect stock of human capital. There exists a gap in the context of measure of human capital with more recent measure of human capital stock. This study is a bridge to cover this gap by estimating long run relationship between human capital stock and economic growth.

3. Model, Methodology and Data

This study uses augmented Cobb Douglas production function of Mankiw et al. (1992) to check the long run relationship between factor accumulation and GDP per worker. The properties of time series data are evaluated using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. Moreover, autoregressive distributive lag (ARDL) bound test is used to observe cointegration among variable (factor accumulation).

3.1 The Model

Empirical relationship between measures of human capital and GDP per worker is investigated by using Mankiw, Romer, and Weil (1992) version of human capital augmented Cobb Douglas production function.

$$GDP_t = A_t K_t^{\alpha} (L_t H_t)^{\beta} \quad (3.1)$$

Where, GDP_t represents real GDP and K_t, A_t, L_t, H_t shows available real physical capital stock, total factor productivity, employed labor (ages 15-64) and available human capital stock respectively. L_tH_t is effective labor which is an active participant of the production process. α and β are elasticities of physical capital and effective labor. It is assumed that $\alpha+\beta=1$ which means constant return to scale in these two production factors.

Divide equation (3.1) with employed labor force to transform into per worker form as follow:

$$GDP_t/L_t = [A_t K_t^{\alpha}(L_tH_t^{\beta})]/ L_t$$

$$GDP_t/L_t = [A_t K_t^{\alpha}(L_tH_t)^{\beta}]/(L_t^{\beta}. L_t^{\alpha}) \qquad [\alpha+\beta=1]$$

$$GDP_t/L_t = A_t [(K_t)/L_t]^{\alpha}[(L_tH_t)/L_t]^{\beta}$$

$$GDP_t/L_t = A_t (K_t/L_t)^{\alpha} (H_t)^{\beta} \quad (3.2)$$

Taking log of equation (3.2) and we get

$$Ln (GDP_t/L_t) = LnA_t + \alpha Ln (K_t /L_t) + \beta Ln (H_t) \quad (3.3)$$

Where, (GDP_t/L_t) shows GDP per worker, (K_t /L_t) shows real capital stock per worker, H_t shows average year of schooling as a proxy for human capital. We can also write this model as:

$$gdp_t = a_t + \alpha(k_t) + \beta(h_t) \quad (3.4)$$

Hence, the basic econometric model is:

$$gdp_t = a_t + \alpha(k_t)+ \beta (h_t) + u_t \quad (3.5)$$

Where, gdp_t is real GDP per worker, a_t is total factor productivity, k_t, is real physical capital stock per worker, h_t is human capital stock, and u_t is error term which captures unexplained variations.

3.2 Methodology

The study deals with the time series data which need special attention otherwise it will lead towards misleading results and policy implications. In order to avoid the problem of unit root (non-stationary), the study used ADF and PP tests.

3.3 Test of Stationarity.

3.3.1 Augmented Dickey Fuller Test.

Time series data is very sensitive to unit root test because if the series under consideration have unit root then it may yield invalid results and misleading conclusions. Dickey and Fuller (1979) presented Dickey-Fuller unit root test in which they assume that the error term is uncorrelated. But what if the error term are correlated, in order to address this problem Dickey-Fuller presented augmented Dickey-Fuller unit root test in which they augmented their previous test of unit root by adding lag of the dependent variable on the right hand side.

3.3.2 Phillips-Perron (PP) Unit Root Test

In ADF unit root test the problem of serial correlation is encountered by adding lag of the regressand on the right hand side. Phillips and Perron (1988) encounter this problem by using nonparametric statistical methods without adding the lag of the dependent variable.

3.4 Autoregressive Distributive Lag (ARDL) Model

There are various techniques that were used bluntly to check the co-integration between the variables (Engle-Granger, 1987; Johansen & Juselius, 1990; Johansen, 1995) but all these technique require that the variable are integrated of same order. Moreover, if the data sample is small then these traditional cointegration techniques are not reliable. However, to avoid these problems, when the variables are mixture of I(0) and I(1) then there is another technique of cointegration introduced by Pesaran, Shin and Smith (2001) which is known as "Autoregressive Distributive Lag". There are two assumptions of ARDL bound testing approach to cointegration i.e. regressand should be of order I(1) and none of the variable is of order I(2). Violation of these assumptions will give invalid F-statistics as bounds testing approach is based on the assumption that the variables are of order I(0) and I(1) (PSS, 2001). Since, ARDL bounds testing is applied

on mixture of variables integrated of order I(0) and I(1). ARDL bounds testing approach is better than other techniques due to following reasons: firstly, this technique does not require pre testing of the variables i.e. regressors are purely I(0) or I(1) or mutually integrated, secondly, ARDL bounds testing approach gives information of the structural breaks in the series, thirdly, Error Correction Model (ECM) is derived from ARDL by a simple linear transformation and error correction term (ECT) integrate short run adjustments with long run without losing the long run information, finally, it gives more accurate result than usual integration techniques because in the presence of mixture of I(0) and I(1) standard co-integration techniques yield unstable results (Ahmed, 2008).

Specification of ARDL model:

$$\Delta \text{Log } Y_t = \lambda_0 + \sum \alpha_i \, \Delta \log Y_{t-i} + \sum \beta_i \, \Delta \log HC_{t-i} + \sum \gamma_i \, \Delta \log K_{-t-i} + \sum \varphi_1 \log Y_{t-1} + \sum \varphi_2 \log HC_{t-1}$$

$$+ \sum \varphi_3 \log K_{t-1} + e_t \qquad (3.6)$$

This is the dynamic linear equilibrium model. Where, on the right hand side the terms with Δ shows the first difference of the lagged variables. α, β, and γ are representing the short run dynamics and φ_1, φ_2, and φ_3 are long run coefficient which shows marginal change in dependent variable due to change in explanatory variables. In order to test the cointegration, the following null hypothesis is tested:

H_0: $\varphi_1 = \varphi_2 = \varphi_3 = 0$ (There is no cointegration)

H_1: $\varphi_1 \neq \varphi_2 \neq \varphi_3 \neq 0$

F-statistics are compared with the upper bounds and lower bounds, if the value of F-statistics falls outside the upper bound than one can conclude that there is cointegration exist among the variable by rejecting the null hypothesis and if the value of F-statistics falls below the lower bounds than we cannot reject the null hypothesis. However, if the value of F-statistics falls between the lower and upper bounds then the results will be inconclusive.

3.5 Diagnostics Tests

The strength of the model is tested by conducting diagnostics tests. Breusch-Ggodfrey test is to check the residuals for serial correlation, Breusch-Pagan test for heteroscedasticity, and Reset Specification test for functional misspecification. Moreover, the stability of the parameters of long run and short run is tested by CUMSUM and CUSUMSQ test.

3.6 Construction of Variables

In earlier studies capital stock and human capital stock series are used from secondary source e.g. literacy rate, enrollment ratio, education expenditure, primary and secondary level enrollment ratio are various proxies that were used as human capital but all these proxies do not capture the true stock of human capital. However, theses proxies lead to misleading conclusions. Barro and Lee (1993), and Wang and Yao (2001) address this issue and generated a series in order to capture available human capital stock. However, gross domestic investment, gross fixed capital formation was taken as a proxy to measure real capital stock which does not reflect the true stock of physical capital stock. We have constructed both the series in order to capture stock of both human capital and physical capital.

3.6.1 Construction of Real Capital Stock

In order to construct real capital stock using gross fixed capital formation average rate of depreciation is supposed 5% (Siddiqui, 2004). Real capital stock series is calculated by following formula:

$$K_t = (1-\mu)\, K_{t-1} + I_t \qquad (3.7)$$

Where, K_t is real capital stock in time t, μ is rate of depreciation, I_t is gross fixed capital formation in year t.

In equation (3.7) 'μ' is rate of depreciation and assumed to be constant. While, initial capital stock is calculated using following formula calculated by Schclarek (2004)

$$K_0 = [I_{t-1}/(\mu + AGI)] \qquad (3.8)$$

Where, I_{t-1} is Gross figed capital formation in previous year t-1, AGI is average growth rate of I_t.

Stock of real physical capital is calculated by using equation (3.7) which is relatively better measure than the previously used.

3.6.2 Construction of Human Capital Index

Wang and Yao (2001) used perpetual inventory method to calculate human capital stock for China. This study follows Wang and Yao (2001) methodology by considering annual number of graduates as a flow variable that is added to existing human capital stock. According to Barro and Lee (1993) number of graduates reflect more accurate image about the addition of new stock to the existing human capital stock than the gross or net enrollment ratios used by Lucas (1986), Romer (1990), Abbas (2000), and Khan (2005). In the construction of human capital stock, we take account annual number of graduates and duration of each level of schooling. Using education enrollments, we calculate average years of schooling for five categories: primary, middle, secondary, college and university and the duration for these categories is assumed to be 5, 8, 10, 12, and 16 respectively. Attainment for primary level education is calculated by using the formula given below:

$$H_{1,t} = (1- \gamma)H_{1,t-1} + (Pri_t - Mid_{t+3}) \quad (3.9)$$

Where, γ is mortality rate, $H_{1,t}$ is attainment of primary level education, Pri_t is enrollment of primary level and Mid_t is enrolment of middle level. However, calculating attainment, duration of each level of education is also taken into consideration e.g. if Pri_t is 1980, then Mid_{t+3} is 1983, because duration of middle level education is three years.

Similarly, attainment for middle level education is calculated by using the formula given below:

$$H_{2,t} = (1- \gamma)H_{2,t-1} + (Mid_t - Sec_{t+2}) \quad (3.10)$$

Where, $H_{2,t}$ is attainment of middle level education, and Sec_t is enrolment of high school education. As the high school education is of two years (IX-X) that's why we subtract Sec_{t+2} from current middle enrollment Mid_t to get attainment for middle level e.g. if Mid_t is 1980 than Sec_{t+2} is 1982.

Attainment for secondary level education is calculated by using the formula given below:

$$H_{3,t} = (1- \gamma)H_{3,t-1} + (Sec_t - Coll_{t+2}) \quad (3.11)$$

Where, $H_{3,t}$ is attainment of secondary level education, and $Coll_t$ is enrolment of colleges. As the college level education is of two years (XI-XII) that's why we subtract $Coll_{t+2}$ from Sec_t to get attainment for secondary level e.g. if Sec_t is 1980 than $Coll_{t+2}$ is 1982.

Attainment for colleges is calculated by using the formula given below:

$$H_{4,t} = (1- \gamma)H_{4,t-1}+ (Coll_t - Uni_{t+2}) \quad (3.12)$$

Where, $H_{4,t}$ is attainment of college level education, and Uni_t is enrolment of universities. As the university level education is comprises on two years of bachelor degree and two years of master degree. Thus we take mean of university level education i.e. Uni_{t+2}.

Attainment for university level education is calculated by using the formula given below:

$$H_{5,t} = (1- \gamma)H_{5,t-1} + Uni_t \quad (3.13)$$

Where, $H_{5,t}$ is attainment of university. H_{jt} represents the annual number of graduates with high education level j by the person. If a person did not complete his J^{th} level of education then he/she will be consider being completed his lower level of education which is (j-1).Using above formulas and educational enrollment of Pakistan we can generate the series of educational attainment and define human capital index for Pakistan as:

$$H_t = (8H_{2,t}+10H_{3,t}+12H_{4,t} +16H_{5,t})/Pop_t \quad (3.14)$$

Average year of schooling is calculated by excluding attainment of primary level because it calculates the average year of schooling for the population group between ages (15-64) which does not include the population enrolled in primary level. There will be a technical error if it includes attainment of primary level education but did not include population of that age group. In order to avoid this error an alternative series for human capital is calculated which measures average year of schooling by including attainment of primary level education and represents the average year of schooling of total population.

$$H_t = (5H_{1,t}+8H_{2,t}+10H_{3,t}+12H_{4,t} +16H_{5,t})/\text{Total Population} \quad (3.15)$$

3.7 Data

The study used time series data for Pakistan from 1973 to 2014 at annual frequency. Data for employed labor force is collected from Handbook of Statistics (2010) and Pakistan Economic Survey (various issues). Fixed capital formation is collected from Handbook of Statistics (2010) and Pakistan Economic Survey (various issues). Real GDP is collected from Pakistan Economic Survey (various issues). Enrollment at different level of education i.e. primary, middle, secondary, colleges and universities is taken from Handbook of Statistics (2010) and Pakistan Economic Survey (various issues). Mortality rate and population between ages 15-65 is calculated by using World Development Indicator (WDI) data.

4. Results

4.1 Unit Root Tests

ADF and PP unit root tests are most widely used tests for checking the unit root of the time series. These unit root tests are conducted to verify that our data series are not violating the assumptions of ARDL bound testing approach that none of the variable is I(2). The results of the unit root tests show that explanatory variables (human capital and real physical capital stock) are integrated of order I(0), while dependent variable is I(1). Results of the ADF test are verified by Phillips-Perron unit root test and given in table 4.1.

Table 4.1 Results of ADF and PP Unit Root Tests

Variables	Augmented Dicky Fuller		Phillip-Perron		Order of Integration	
	At Level	At 1st Difference	At Level	At 1st Difference	ADF	PP
Ln GDP	-1.218480 [0.6574]	-6.321608 [0.0000]	-1.457865 [0.5446]	-6.323023 [0.0000]	I(1)	I(1)
Ln HC	-17.11752 [0.0000]	-	-9.573877 [0.0000]	-	I(0)	I(0)
Ln HC1	-3.053777** [0.0387]	-	-13.70448 [0.0000]	-	I(0)	I(0)
Ln K	-11.62674 [0.0000]	-	-9.608948 [0.0000]	-	I(0)	I(0)

4.3 Bound Test for Co-integration

After conducting unit root test, bound test to co-integration is applied. For this purpose unrestricted ECM model is constructed. Specification of unrestricted ECM model is as follow:

$$\Delta \text{Log } Y_t = \lambda_0 + \sum \alpha_i \, \Delta \log Y_{t-i} + \sum \beta_i \, \Delta \log HC_{t-i} + \sum \gamma_i \, \Delta \log K_{-t-i} + \sum \varphi_1 \log Y_{t-1} + \sum \varphi_2 \log HC_{t-1}$$

$$+ \sum \varphi_3 \log K_{t-1} + e_t \qquad (4.1)$$

To test the co-integration, the following null hypothesis is tested (i.e. coefficients of the lagged variables are equal to zero).

H_0: $\varphi_1 = \varphi_2 = \varphi_3 = 0$ (There is no co-integration)

H_1: $\varphi_1 \neq \varphi_2 \neq \varphi_3 \neq 0$

Table 4.2 reports the results of unrestricted ECM model.

Table 4.2 Unrestricted ECM Model Estimation

Dependent Variable: ΔLGDP			
Variable	Coefficient	t-Statistic	Prob.*
ΔLGDP(-1)	0.61105	11.8824	0.0000
ΔLHC	0.15904	4.36796	0.0001
ΔLK	0.83327	8.45066	0.0000
ΔLK(-1)	-0.73597	-8.61671	0.0000
C	3.10365	4.33849	0.0001
R-squared	0.995665		
F-statistic	2066.920		

To check for co-integration bound test is applied using (1,0,1) model specification (lag selection according to SIC). After applying bound test F-statistics is computed and compared with the upper bounds and lower bounds values (5% level of significance) as suggested by Pesaran (2001). Observing F-statistics (table 4.3) one can see that its value is 31.41 which falls above the

upper bounds at 1% level of significance (6.36). So, we can reject the null hypothesis of no co-integration. We find evidence of strong co-integration that there exist long run equilibrium between the variables. Results of the bound test are reported in table 4.3.

Table 4.3 ARDL Bounds Test

Test Statistic	Value	k
F-statistic	31.41488	2
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

4.4 Diagnostic Tests

After establishing long run relationship, the parameters of the long run will be estimated by using ARDL approach. But it is necessary to check diagnostic tests for serial correlation (LM serial correlation test), heteroscedasticity (White test for heteroscedasticity), model specification error (Ramsey RESET) to avoid misleading conclusion (results are reported in table 4.4).

Table 4.4 Results of Diagnostic Test

Test	F-statistics (p-values)	Null Hypothesis
Breusch-Godfrey Serial Correlation LM Test:	1.293867 (0.2882)	No serial correlation
Heteroscedasticity Test Breusch-Pagan-Godfrey	0.546749 (0.7025)	No Heteroscedasticity
Ramsey RESET Test	0.357362 (0.7230)	Model is Correctly Specified

F-statistics and p-values conclude that unrestricted ECM model is not suffering from serial correlation, heteroscedasticity and model specification error. In each test one cannot reject the null hypothesis.

4.5 Estimation of Long Run Dynamics

Bound test conclude that factor accumulation and GDP per worker is co-integrated, so long run parameters are estimated by using equation (4.2) as:

$$\text{Log } Y_t = \delta_0 + \sum\delta_1 \log Y_{t-1} + \sum \delta_2 \log HC_{t-1} + \sum \delta_3 \log K_{t-1} + e_t \qquad (4.2)$$

$$\text{LogY} = 7.97976370 + 0.4088*\text{logHC} + 0.2501*\text{logK}$$

The coefficient of human capital is positive and statistically significant meaning that it can accelerate economic growth in the long run. One can say that 1% increase in stock of human capital can increase economic growth by 0.41 %. Real capital stock per worker is also positively associated with the economic growth and coefficient of capital stock shows the marginal change in GDP per worker due to 1% change in the real capital stock per worker (table 4.5).

Table 4.5 Estimation of Long Run Dynamics

Variable	Coefficient	t-Statistic	Prob.
D(LHC)	0.159034	4.367926	0.0001
D(LK)	0.833275	8.450660	0.0000
CointEq(-1)	-0.388941	-7.563233	0.0000
Coint Eq. = LGDP - (0.4089*LHC + 0.2502*LK + 7.9798)			
Long Run Coefficients			
LHC	0.408891	6.926205	0.0000
LK	0.250163	2.777450	0.0086
C	7.979764	7.664947	0.0000

Results of this study are consistent with the previous studies conducted in Pakistan (Abbas, 2001: Khan, 2005: Afzal et.al, 2010 and Ali et.al, 2011). All these studies concluded that human capital influence economic growth positively.

4.6 Estimation of Short Run Dynamics

Short run coefficients are estimated by transforming the ARDL model. Error Correction Representation of ARDL model is:

$$\Delta \text{Log } Y_t = \alpha_0 + \sum \gamma_i \Delta \text{logK}_{-t-i} + \sum \lambda_i \Delta \text{logHC}_{-t-i} + \text{ECT}_{t-1} + e_t \quad (4.3)$$

$$\Delta \text{Log } Y_t = 0.02187 + 0.0758 * \Delta \text{logHC} - 0.1432 * \Delta \text{ LK} - 0.2484 * \text{ECT}$$

In equation 4.3 lagged value of ECT shows the speed of adjustment. In above ECM model ECT is 0.254 meaning that 25% of shocks can be restored after any disturbance in the short run. Estimates of short run dynamics are given in table 4.6.

Table 4.6 Estimation of Short Run Dynamics

Variable	Coefficient	t-Statistic	Prob.
C	0.021813	3.640480	0.0008
ΔDHC(-1)	0.075883	0.620805	0.5386
ΔDK(-1)	-0.143293	-0.927216	0.3600
U(-1)	-0.249401	-3.431407	0.0015

The findings of this study are consistent with the endogenous growth theory developed by Locas (1986) and Romer (1988) that human capital is the main source of GDP. Our long run and short run coefficient reveals the fact that development of human capital is necessary to put the country on growth track.

4.7 Stability Tests

The stability test is applied on the ECM residuals. Figure (4.1 and 4.2) shows the stability of the parameters. Bahmani and Nasir (2004) checked the parameters of ECM for stability under the null hypothesis (the regression equation is correctly specified). We will reject the null hypothesis if the stability test cross critical bounds of the 5 percent significance level. Figure 4.1 and 4.2 shows CUSUM and CUSUMSQ respectively and showing that parameters are stable.

Figure 4.1 CUSUM Test

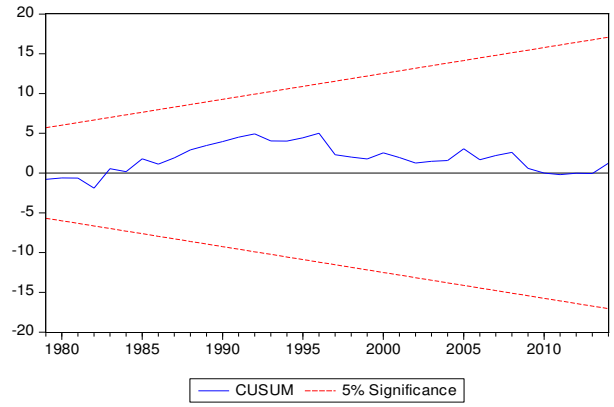
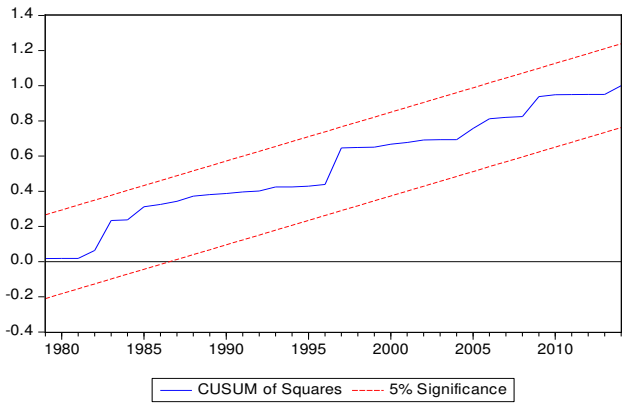


Figure 4.2, CUSUMSQ Test



4.8 Robustness Analysis

As there are two proxies constructed for human capital using attainment of different level of education. ARDL model with alternative proxy for human capital (unrestricted ECM) is specified as:

$$\Delta \text{Log } Y_t = \lambda_0 + \sum \alpha_i \, \Delta \log Y_{t-i} + \sum \beta_i \, \Delta \log HC1_{t-i} + \sum \gamma_i \, \Delta \log K_{-t-i} + \sum \varphi_1 \log Y_{t-1} + \sum \varphi_2 \log HC1_{t-1}$$

$$+ \sum \varphi_3 \log K_{t-1} + e_t \qquad (4.4)$$

In equation (4.4) is the term 'HC1'is proxy for human capital, rest of the model remain as it is.

ARDL model is estimated (bound testing approach to co-integration) and F-statistics are compared with the upper bounds and lower bounds. Table 4.7 and 4.8 report the results respectively.

Table 4.7 ARDL Model Estimation

Variable	Coefficient	t-Statistic	Prob.*
LGDP(-1)	0.595735	12.50511	0.0000
LHC1	0.132938	5.148306	0.0000
LK	0.909251	9.551943	0.0000
LK(-1)	-0.765118	-9.416147	0.0000
C	2.695602	5.008788	0.0000
R-squared	0.996180		
F-statistic	2346.816		

Table 4.8 Bounds Testing for Co-integration

Test Statistic	Value	k
F-statistic	34.43562	2
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Results of the bound test suggest that there exist strong co-integration among the variables under consideration. Estimates of long run parameters are given in table 4.9. Results shows that coefficient of human capital is positive and statistically significant. An economy would be in equilibrium in the long run if it grows gradually. One can say that 1% increase in stock of human capital can increase economic growth by 0.32 %. Real capital stock is also positively associated with the economic growth and coefficient of capital stock shows that there will be 0.35% marginal change in GDP per worker due to 1% change in the real capital stock.

Table 4.9 Estimation of Long Run Dynamics

Variable	Coefficient	t-Statistic	Prob.
D(LHC1)	0.132938	5.148306	0.0000
D(LK)	0.909251	9.551943	0.0000
CointEq(-1)	-0.404265	-8.485946	0.0000
Coint Eq = LGDP - (0.3288*LHC1 + 0.3565*LK + 6.6679)			
Long Run Coefficients			
Variable	Coefficient	t-Statistic	Prob.
LHC1	0.328839	8.223847	0.0000
LK	0.356532	5.554759	0.0000
C	6.667909	9.022100	0.0000

Table 4.10 Estimation of Short Run Dynamics

Variable	Coefficient	t-Statistic	Prob.
C	0.021713	3.573229	0.0010
ΔDHC1(-1)	0.069935	0.559053	0.5796
ΔDK(-1)	-0.133184	-0.871800	0.3891
U(-1)	-0.251974	-3.333778	0.0020
R-squared	0.255258	Durbin-Watson stat	1.919385
Adjusted R-squared	0.193196	Prob(F-statistic)	0.013146
F-statistic	4.112956		

Net effect of the both proxies of human capital remains the same. Both proxies influence economic growth positively and significantly. Although computation of both proxies is different but both proxies for human capital suggest that human capital is a main source for economic growth supporting endogenous growth theory.

Estimates of short run parameters are given in table 4.10. The absolute value ECT shows speed of adjustment and the negative sign shows convergence. The coefficient of ECM is 0.252 and which means that 25% of shocks can be restored. Negative and significant ECT term shows that economic growth, real capital stock and human capital are cointegrated when economic growth is taken as dependent variable. 0.0699 shows the marginal change in GDP per worker due to 1% change in HC1.

4.11 Conclusion

The objective of the study is to analyze the relationship between factor accumulation and GDP per worker in Pakistan using ARDL bound testing approach to co-integration from 1973 to 2014. ADF and PP unit root tests conclude that data series are stationary at level except GDP per worker which has unit root at level but becomes stationary at first difference. The purpose of the unit root test is to confirm that data series are not violating the basic assumptions of ARDL approach to co-integration i.e. none of the variable is I(2) and dependent variable should be I(1). Unrestricted ECM is estimated to perform bounds test and computed F-statistics using bound test proves the evidence of co-integration among the variables under consideration. Residuals are checked for diagnostic tests before calculating long run and short run coefficients. These tests show that ARDL model is free from serial correlation, heteroscedasticity, and mis-specification error. Long run coefficients are calculated under ARDL approach. Coefficient of ECT suggest that the speed of adjustment is 25%, which means that 25% shocks will be restored due to any disturbance in the short run. Both human capital stock and real capital stock come out to be significant and growth friendly in the long run. CUSUM and CUSUMSQ tests proves that our estimated parameters are stable. Robustness analysis is performed using alternative proxy for human capital. Use of alternative proxy for human capital cannot alter the results and main conclusions of this analysis but it confirms results and conclusions.

Real capital stock has a long run relationship and it effects positively to GDP per worker in the long run as it does in the previous studies conducted by Chow (1993), Abbas (2000), Wang and Yao (2001) and Khan (2005), whereas it does not have any short run effect on GDP per worker. Developing countries should increase share of physical capital for economic development. In Pakistan government should increase share of GDP for development and infrastructure as it will

improve standard of living of the people. Increasing stock of real capital stock will increase level of employment which will rise per capital income and ultimately improve the standard of livings. This study suggests that there is a long run relationship between GDP per worker and stock of human capital. Proxy for human capital is effecting GDP per worker positively and significantly in the long run, it can contribute to economic growth in the long run as suggested in the previous studies by Lucas (1988), Romer (1990), Mankiw et.al (1992), Abbas (2000), Khan (2005), Ali et al. (2012) and Qadri and Waheed (2014). As Human capital (average year of schooling) increase labor productivity by acquiring knowledge and training, which will attract other factor of production like physical capital and in this way human capital cause productivity growth which leads to increase employment level, per capital income and hence economic growth.

5. Conclusion and Policy Implications

Over the last three decades human capital (as a factor of production) has been the primary focus in both theoretical and applied research. Generally, development of human capital in developing countries is necessary to boost the economy. Endogenous growth theory highlighted the importance of human capital after Mincer (1958) and Schultz (1961) by considering it as an important factor of production. The rate of development of human capital remained slow in Pakistan since independence. Pakistan remain less efficient to accelerate its economy comparative to other developed countries that consider human capital as primary source of growth.

This study explores the relationship between factor accumulation and GDP per worker in Pakistan under the autoregressive distributive lag model from 1973 to 2014. This study also address the problem with the traditional proxies used in different studies. Findings of this study suggests that human capital, physical capital and GDP per worker are co-integrated meaning that there exist long run relationship between factor accumulation and GDP per worker. Both physical capital and human capital are important sources of economic development in Pakistan. Endogenous growth theory rejected the traditional views that economic growth is determine by exogenous factor (technological changes) and suggest that economic growth is determine by endogenous factors. Endogenous growth theory came with a new direction for theoretical and empirical research. Findings of this study are consistent with the previous studies of Lucas

(1988), Romer (1990), Barro (1991), Mankiw et.al (1992), Abbas (2000), Khan (2005), Ali et al. (2012) and Qadri and Waheed (2014). All these studies support endogenous growth theory. From the results we found that human capital is growth friendly. Apparently this study is consistent with the previous studies conducted in Pakistan but our measure of human capital relatively much better. As we have constructed human capital measure as average year of schooling by considering annual number of graduates at each level of education. Based on the above discussion and conclusion we can outline the following policy implications.

Firstly, our human capital which is embodied by labor force (effective labor force) comes up with the significant and positive relation with economic growth suggest that government should invest on education sector in order to produce more effective and trained labor force.

Secondly, capital stock variable is also significant and positive with the economic growth in the long run so, government is recommended to design its policy which will attract capital inflow and development of infrastructure. Available human capital stock should use it efficiently to enhance economic growth.

Thirdly, government should increase education and health budget to improve schooling and higher education as well as to meet better health facilities in the hospital. As suggested by the Fogel (1994), a person with education and good health can be an active participant of the production process.

Fourthly, government ensures mandatory education up to secondary school and by increasing education budget government should announce free education up to graduation level.

Fifthly, developing countries have poor R&D sector, therefore a significant portion of budget should be allocated for research.

Lastly, government takes some serious steps in order to stop the outflow of human capital. Government should facilitate all the trained and skilled work force because they can significantly contribute to economic growth.

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