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Contribution of female human capital in economic growth: an empirical analysis of Pakistan (1972–2012)

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Abstract This study is to find out an impact of female human capital on economic growth of Pakistan. The study has therefore, used gender separate human capital as an explanatory variable along with other factors, labor force and physical capital. In this regard a composite human capital has been constructed by taking education and health as a proxy for human capital. The long run and short run dynamics among female human capital and economic growth are empirically tested on time series data spread from 1972–2012. Johanson's co-integration approach has been applied for the long run and Vector Error Correction Model used for the short run relationship. The results show that the long run relationship between female human capital and economic growth is positive and significant. While the short run impact of female human capital on economic growth is positive but statistically insignificant.

Keywords Economic growth · Gender separate human capital · Education · Health and economic growth

1 Introduction

Human capital is a complex concept. It has many dimensions and can be acquired by different ways. A variety of definitions of human capital prevailed in economic literature. In general, it is a combination of the God gifted abilities and the learning of knowledge and skills, one acquires and develops throughout the lifetime (Laroche et al. 1999).

Recent economic literature's interest in human capital generally revolves around the economic growth. Numerous empirical studies have been conducted in this regard, to establish the relationship between human capital and economic growth. Moreover, human capital is also used as a driving force to attract other factors such as physical capital and

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technology. These factors are also considered very important to contribute in raising income level. This approach of accumulating physical capital through human capital is more useful and productive for poor countries because effective use of physical capital is possible only with trained and skilled manpower. Accumulation of physical capital depends upon human capital endowment. If there is under investment in human capital, there will be limited or under-utilization of physical capital (Lucas 1988). He has suggested that poor countries are facing the problem of short of physical capital due to inadequate resources of complementary human capital.

Role of human capital has a general acceptance and has been acknowledged being one of the important factors to determine economic growth and the means to acquire human capital by increasing educational attainment and improving health status. In contrary, gender separate human capital is quite conflicting regarding its role in economic growth.

The conventional wisdom of developed economies is that an investment on female education and health in developing countries is more rewarding compare to investment on male (Knowels et al. 2002). The better use of the world's female population, not only promotes economic growth but also facilitate social uplift of the society. Thus the third (out of eight) millennium development goal is to promote gender equality regarding opportunities. Such equality will empower women socially and economically. It will therefore, help to reduce poverty, enhance human well-being, and ensure sustainable economic growth. The general perception is that the female half of the population is undervalued and underutilized in the growth process all over the world. Therefore, the countries do not explore or capitalize the full potential of one half of their societies are misallocating their resources. This gender inequality is quite visible in developing countries and is considered as one of the major hindrance in their economic growth (Morrison et al. 2007).

Gender equality means equality in opportunities and access to basic rights. It does not mean equality in output or efficiency (Chaudhary 1975). The available opportunities and access to basic right will help to determine the level of human development. The gender inequality index indicates that gender equality of basic rights is weaker in developing countries either due to poor development policies or lack of effective implementation of these development policies compared to developed economies. It restricts the country's economic and social uplift. The role of gender equality has therefore, been emphasized as an essential component of effective economic and human development strategies.

Inequality has different dimensions from basic rights to economic and social opportunities, which varies from country to country. There are intra-household disparities as well. These are usually in the form of food distribution, decision making, assets ownership, investment on male and female members etc. In poor households, female children are subject of chronic malnutrition and additional suffering of unequal opportunities to education and health.

Pakistani society is also subject of gender inequality and females suffer from unequal opportunities in health, education, nutrition and in control over productive resources. All these disparities inhibit females to reach their optimum potential and productivity. Male members of the family are preferred in education, quality food for good health and facilities to acquire skill due to their more productive role in the society. So to empower the role of female in a society, it is very important to provide parallel opportunities regarding education, health and acquiring skill. Pakistan's overall, economic performance in social sector has never been very commendable since its independence 1947. In 1960s, comparatively overall better economic performance has been registered in Pakistan's economic history, which has not been retained. However, after the 1965 war with India, the spending

on defense has been increased. While the education and health sectors have faced a sharp cut in their expenditure. The responsibility of poor performance in basic education can also be put on the nationalization of private educational institutions in 1972.

Social sector is still the most neglected sector of the Pakistan economy. Among South Asian countries, Pakistan has one of the lowest overall public expenditures 2.4 % of GDP on education and 0.8 percent of GDP on health sectors. Whereas, in India 3.1 % of their GDP is allocated on education and 1.2 % of their GDP's on health. Even Bangladesh is spending 2.2 % of GDP on education and 1.2 % on health (UNDP 2013).

According to Human Development Index (HDI), which is a three dimensional measure of basic achievements in health, education and living standard. Pakistan is ranked 146 out of 186 countries. At the same time, India and Bangladesh are ranked 136 and 146 respectively. As per Gender Inequality Index (GII), which reflects three dimensions of inequality such as, reproductive health, empowerment & economic activity, Pakistan is ranked 123 out of 146 countries. Whereas, Bangladesh is ranked 111 and India is ranked at 132 in the world ranking (UNDP 2013). It shows that women of subcontinent are far behind men in acquiring empowerment and labor participation.

2 Literature review

There is a vast literature available on theoretical and empirical studies of economic growth. It has numerous determinants and continuously expanding in different dimensions. It ranges from neoclassical exogenous growth models Solow (1956) and Swan (1956) to endogenous growth model Romer (1994) to empirical estimation. The studies have become more specific and refined by incorporating variety of variables and using advanced estimation techniques.

There is a general perception that economic growth is not possible without accumulation of human capital. But early growth theories mostly used labor and physical capital as the main determinants of economic growth. Emphasis on human capital being a determinant of economic growth has started in late 1980s and early 1990s and have further extended to gender neutral and gender specific human capital. We will briefly review here first, the role of gender neutral human capital in growth models.

2.1 Gender neutral human capital in growth literature

Lucas (1988) has emphasized the role of human capital along with labor and physical capital as inputs in his endogenous growth theory. He considered that economic growth could not be achieved without accumulation of human capital and argued that the economic growth rate varied among different countries because the difference in their capital accumulation. In 1988, he developed growth model by using Solow (1956) model based on same assumptions that economy consisted on identical individuals with objective to maximize their life time utilities. He just replaced technology with human capital. While individuals have freedom to allocate their time between acquiring skill to improve their efficiency or they might prefer to work. Lucas proposed the model:

$$y_t = AK_t^{\alpha}(u_t h_t L_t)^{1-\alpha} h a_t^{\gamma}$$

U_t indicates that how much time an individual has allocated to work at time t and existing level of human capital at time t has been represented by h_t. Whereas, h_a is average

human capital in an economy over the period t and not the subject of diminishing marginal returns. Lucas (1988) has taken primary education as a driving force to accumulate human capital and has considered as an additional determinant of economic growth along with labor and physical capital.

The most promising empirical growth study which has considered human capital as determinant of economic growth is by Mankiw et al. (1992). The model has an empirical implication of Solow (1956) and Swan (1956) theoretical growth model. They have assumed a Cobb-Douglas production function having conventional variables labor and physical capital along with human capital as main inputs. Population growth rate and technological progress have taken as exogenous determinant of economic growth. The general form of augmented human capital given below:

$$Y_t = K_t^{\alpha} H_t^{\beta} (A_t L_t)^{(1-\alpha-\beta)}$$

Mankiw et al. (1992) have assumed a production function exhibited constant returns to scale but diminishing returns to production factors. The augmented growth model has better explanatory ability than conventional growth model and has shown higher human capital elasticity of growth compare to other inputs. More importantly, they have found that human capital accumulation has positively affected the level of income per worker and in the transition to the steady state economic growth.

The concept of capital has broadened by including human capital. Similarly, human capital has also extended by including health along with education as components of human capital. Knowles and Owen (1995, 1997) have applied extended human capital in their models based on Mankiw et al.'s (1992) model.

The most promising contribution through empirical research in the literature of human capital and economic growth has been conducted by Barro (1991). His research work on growth theory has not been categorized entirely as an empirical research. He has also derived few theoretical models to support his justification about the variables to be added in the growth model. Though the proxies used for these variables have not been theoretically justified. Barro and Sala-i-Martin (1992) have discarded the unconditional convergence theory as the evidence has not been supportive of this absolute convergence. As per convergence theory, developing countries have not grown faster than developed economies. Barro (1991) has therefore, developed growth model in which initial income level and initial human capital level, equally influence economic growth. Regression results have supported the model and growth rate has been found positively related to human capital. Proxy used for human capital is the enrolments at secondary school level.

Bernanke and Gurkaynak (2001 have re-examined the Mankiw et al. (1992) framework and has different conclusion. They have also applied OLS method and used a Cobb–Douglas production function having same variables and also have same proxy used for human capital in the Mankiw et al. (1992) framework. The results have not been similar to augmented version of Solow (1956) model developed by Mankiw et al. (1992). It has been found that the growth rate has shown long run relationship with behavioral variables (like saving rates). So the results have ended up in the support of long run endogenous growth theory.

Wang and Yao (2001) have found that China's sustained growth has not an outcome of just accumulation of factors of production but also caused by total factor productivity (TFP) growth in the post reform period of 1978–1999. This study has applied growth accounting technique by taking growth of all inputs labor, capital and human capital but growth in TFP has been represented by the residual. An average year of schooling has

taken as a proxy for human capital. They have concluded that during the pre-reform period (1953–1977) TFP has negative effect on growth and factors accumulation have contributed in growth. But post reform growth has not been only due to factor accumulation, it has also been supported by TFP growth.

Duma (2007) has analyzed the sources of growth in Sri Lanka. His study has comprised on annual data from 1980 to 2006. He has applied growth accounting technique at augmented growth model. The total output as a proxy of growth, has taken as an explained variable. While, explanatory variables have been growth of all inputs such as labor, physical capital and human capital. Moreover, the unexplained variations as total factor productivity in the model have been represented by residual in the equation. Author has not taken, average years of schooling as a proxy for human capital but has constructed a variable with different process and have concluded that it has a very little contribution in economic growth. The study over the period from 1980 to 2006 has represented that after the major contribution of unexplained variations of 46 %, growth of physical capital has contributed 27 % in economic growth. While, labor has contributed 17 % and human capital has contributed only 10 % in economic growth. The findings have been supported by the reality that mechanization in early 1980s, have replaced the labor intensive production techniques with capital intensive ones.

Abbas and Foreman-Peck (2008) have estimated the effect of human capital on economic growth of Pakistan by using co-integration techniques from 1961 to 2003. In this study, they have used two separate proxies for human capital, one is the secondary school enrolment and another is health expenditure have been taken as a percentage of GDP. They have concluded that physical and human capital has positive influence on economic growth with higher investment on health.

Madsen et al. (2008) have a study on Indian growth using a data set from 1950 to 2005. They have used augmented production function to find an evidence of endogenous growth in India. Their endogenous growth hypothesis has not strongly supported by findings that the TFP and research activity have no long run relationship. They have also identified an international influence on Indian economy.

Qadree and Waheed (2011) have used composite human capital. Their study has supported the finding that human capital has long run positive relationship with economic growth in Pakistan. They have used health expenditure and primary enrolment as proxy for human capital in their study and concluded positive influence of human capital on economic growth. The focus of their study has been to address the health and education sectors of the economy simultaneously.

Rehman et al. (2012) have contributed to fill the gap in literature regarding role of human capital in economic growth of Pakistan. They have used two separate proxies, health and education for human capital. Results have shown the strong evidence of positive relationship between human capital and economic growth. They have therefore, recommended to spend more on human capital to achieve a sustained economic growth in Pakistan.

2.2 Gender specific human capitalin growth literature

Female and male education and health have been used in number of micro studies to analyses their social impact. According to Blau (1986), Cain and Weininger (1973), fertility has been decreased due to increase in female education. Educated and healthy mothers have positive influence on health, education and welfare of the next generation of their children (Behrman and Deolalikar 1988, Schultz 1988 and Behrman et al. 1999). Fall

in fertility rate has caused increase in average life expectancy and lowered infant mortality rate (Blau and Robins 1989, Behrman and Deolalikar 1988). As per Psacharopoulos and Patrinos (2002), rate of return's analysis in Microeconomic has also supported the benefits of female education. The study has concluded positive returns to education, while female education returns relatively higher than male.

Benavot (1989) has realized the shortcoming of the literature that models developed to find the effect of education on economic growth have not properly addressed the gender issues. Barro and Lee (1994) has an extensive often cited research on role of human capital in economic growth. They have found that, economic growth has not an identical influence of both male and female on human capital. Male education has influenced economic growth positively, while in contrary, female influenced economic growth negatively. The finding has implied that investment on female education would lower the economic growth.

Stokey (1994) has suggested an alternative explanation for this puzzling result. Lorgelly and Owen (1999) have tested the validity of Stokey's finding empirically. Barro and Lee (1994) model has not been constructed on detailed diagnostic testing to know authenticity of the model and reliability of the coefficient.

Barro and Sala-i-Martin (1995) and Barro (1996a, b) have used Barro and Lee (1994) model, with its variations by employing variety of variables for the proxies of human capital. They have used secondary and higher education for male and female separately along with life expectancy for human capital. They have similar results as concluded by Barro and Lee (1994) that male education (secondary and higher) has positive and significant coefficient, while the female education (secondary and higher) has negative and significant coefficient. Moreover, the later contribution of Barro (1997, 1998, 1999) with revised updated data, Barro and Lee (1996) have surprisingly different results showing that the female education has not even significantly related to the growth.

Barro and all his supporters have agreed on the notion that the economic growth would fall in case of increase in female education. At the same time few others economists Birdsell et al. (1997) have totally different findings. Their results have shown that male and female human capital equally effective for economic growth. Caselli et al. (1996) have identified an inconsistent estimation in gender specific human capital literature. Their working has based on augmented Solow (1956) growth model, following Mankiw et al. (1992) and in line with Barro and Lee (1994). They have concluded that the female education has affected human capital growth and fertility rate. It has been documented that an adverse female education and fertility rates relationship and fertility rate with growth rate have also equally strong negative relationship. While male education has only human capital effect. They have therefore, openly admitted that no theory has consistency regarding signs for male and female human capital.

Dollar and Gatti (1999)'s finding has supported the argument of gender inequality to be harmful for growth. Their study has used different proxies of education as a human capital and has used the percentage of female and male population for whom primary or in some cases secondary school education is the highest level of educational attainment. They have estimated the relationship between genders based human capital and economic growth for less developed and more developed countries and the whole sample. They have found weak and negative male education and weak but positive female education coefficients in estimating the growth equation for the full sample. More developed economies have negative and not significant coefficient for male secondary education. While positive and significant coefficient have been estimated for female education. It has led them to conclude that the gender inequality is harmful for growth, entirely opposite of Barro and Lee (1994)'s

findings. They have suggested for more investment on female education and health to achieve higher economic growth in developing countries.

Sufficient literature is not available regarding the impact of gender specific (female and male) health index on economic growth. The reason may have been the limited access to the health related data for male and female separately. The data available may have not been from some authentic source. In nutshell, very few studies have considered the role of aggregate health in promoting economic growth. The proxies used to measure health indicator include life expectancy, infant and adult mortality.

Lorgelly (1999), has followed the proxies used by Knowles and Owen (1995, 1997), for the female and male health capital index. They have considered average life expectancy of male and female at birth. Lorgelly (1999) however, has admitted the problem of high correlation between female and male health capital measures. She has also shown her reservation about the quality of gender-separate data. Sen (1990) has also expressed the similar consents about the reliability of the data on female life expectancy. So it would create problem in making some conclusion from working based on such data.

Cooray and Mallick (2011) in their study have concluded that the female human capital stock is influencing economic growth negatively similar to the results in Barro (2001) and have suggested that it has imperative for South Asia to encourage the skill levels and education opportunities for females, in order to maximize the effect of FDI on economic growth. High priority therefore, should be given to female education to maximize the effect of FDI on economic growth. The female human capital stock has not sufficient, threshold required for the transfer of technology through FDI.

Pervaiz et al. (2011) have concluded that the gender discrimination and an inequality have an impact on the growth of an economy of Pakistan. They used composite gender inequality index including educational index, labor participation index and survival index by assigning equal weighting to all three indexes. The results have shown that all variables are significant. While, the factors input labor force, investment on physical capital and globalization have healthy but an adverse effect of gender inequality on economic growth of Pakistan.

Thus the variations in conclusions have kept the issue of gender specific human capital as a determinant of economic growth alive and to evolve further.

3 Theoretical framework

Numbers of model have been developed to incorporate the impact of human capital on economic growth. Lucas (1988) stated that the role of human capital is very vital in economic growth of developing economies. Because the physical capital restrained to flow from developed countries to poor countries due to their relatively poor endowments of complementary human capital. It usually keeps the level of economic growth low in developing economies.

The growth models have therefore, extended to study the impact of human capital on economic growth. Romer (1994) and Barro (1991) have considered human capital the major factor influencing economic growth of a country. While Benavot (1989) has investigated, gender based impact of human capital on economic growth and found that both female and male primary enrolment rates have a positive and significant effect on economic growth. Barro and Lee (1996) have widened the measure of human capital by including both education and life expectancy as the proxy of human capital. They have also

contributed in gender separate human capital by taking primary and secondary education as a proxy and its effect on economic growth.

The focus of this study is to analyze the effect of female human capital on economic growth of Pakistan. Growth model is constructed with segregated human capital (male and female) as explanatory variables. The female human capital and male human capital are composite averages of education index and health index (Construction details are given at Appendix A).

In the light of above stated development in economic growth models, the model used for present study is stated below:

$$GDP_t = f(Cap_t, Lab_t, Fhc_t, Mhc_t) \quad t = 1, 2, 3, \ldots$$

Economic growth is taken as a dependent variable. While, the traditional explanatory variables are physical capital and labor force along with female human capital and male human capital. The specific form of the model in above equation is stated below:

$$GDP_t = A_t\left(Cap_t^{\beta 1}\right)\left(Lab_t^{\beta 2}\right)\left(Fhc_t^{\beta 3}\right)\left(Mhc_t\, t^{\beta 4}\right)$$

where GDP_t is the economic growth at time t, Cap_t is the physical capital at time t, Lab_t is the total labor force at time t, Fhc_t is the female human capital at time t, Mhc_t is the male human capital at time t.

Following equation is a linear expression of above equation by taking log on both sides. Log of GDP is denoted by lower case variable lgdp. Similarly log of Cap, Lab, Fhc and Mhc are denoted by lcap, llab, lfhc and lmhc respectively

$$\lg dp_t = b_0 + b_1 lcap_t + b_2 llab_t + b_3 lfhc_t + b_4 lmhc_t + e_t$$

where b_0 is constant, b_1, b_2, b_3, and b_4 show that how much economic growth will change due to change in factors input physical *capital*, labor force, female and male human capital respectively. Whereas, e_t is an error term at time t.

4 Data and methodology

The data used is a time series data covering the time period from 1972 to 2012. The explained variable is gross domestic product denoted by GDP. It is a proxy for economic growth. Gross fixed capital formation is a proxy for explanatory variable physical capital. Another, explanatory variables are labor force, Female human capital and male human capital. The data for GDP and physical Capital is in Pak rupees at constant price and is taken from WDI World Bank (2013). While the data for labor force and composite human capital based on education and health index is collected from Pakistan Economic Surveys and WDI respectively.

The time series analysis is used to capture and examine the long run dynamics and short run dynamics of long run equilibrium between female human capital and economic growth. First of all the technique has been used to examine stationarity of the trended data before establishing any long and short run relationship between the variables included in the model.

Most of the macroeconomic time series are non-stationary and are categorized trended. The problem with such data, have trend and non-stationarity, gives spurious results. The standard regression procedures give unreliable and incorrect results.

4.1 Unit root test

The method of unit root assumes that mean and variance of variable are constant over time but in case of non-stationary variables mean and variance don't remain constant. They have unit root problem. The augmented version of Dickey Fuller (ADF) is performed to detect the number of unit roots in each variable. ADF test is based on different regression equations.

The ADF test for testing stationarity is a one sided test and can use the hypothesis:

$\mathbf{H_0}$ $\boldsymbol{\beta = 0}$ (y_t is non-stationary)

$\mathbf{H_1}$ $\boldsymbol{\beta < 0}$ (Y_t is stationary)

If the test statistics is less than the critical value than the null hypothesis will be rejected. It implies that the time series is stationary at level. If could not reject the null hypothesis or fail to reject the null hypothesis than the time series is non-stationary at level and it requires to go for first or higher order difference to establish stationarity.

4.2 Johanson co-integration

After testing and confirming the order of integration regarding stationarity of the variables, the next step is to estimate weather there, is a long run relationship between the explained and explanatory variables included in the model. If variables in the model are more than three, the Johansen co-integration approach has been applied to investigate the long run relationship.

The concept of co-integration was initially introduced by Engle and Granger (1987). It was further extended and elaborated by Stock and Watson (1988). While Johanson (1988) and Johanson and Juselius (1990) have contributed by developing a maximum likelihood testing method. Engle and Granger (1987) two steps estimation approach, gives only one co-integrating vector. It was modified by Johanson (1988, 1991) Johanson and Juselius (1990) by suggesting maximum likelihood procedure for number of co-integrating vectors. It also includes testing procedures for linear restrictions on the co-integrating parameters, for any set of variables. This co-integration is applied by using Vector Auto Regressive (VAR) model.

Two types of statistics have been proposed by Johansen's co-integration techniques through VAR model. These are trace test statistics and the maximum eigen-value test statistics used to identify the number of co-integrating vector. The trace statistics tests the null hypothesis that the number of distinct co-integration relationship is less than or equal to 'r' against the alternative hypothesis that of more than 'r' co-integrating relationships. The maximum Eigen value statistics for testing the null hypothesis of at most 'r' co-integrating vectors against the alternative hypothesis of '$r + 1$' co-integrating vectors.

According to Granger (1986), the Error Correction Model (ECM) produces better short run forecasts and provides the short run dynamics necessary to obtain long run equilibrium. The speed of adjustment from the short-run equilibrium to the long-run equilibrium state is indicated by ECM. Its purpose is to show the speed and the direction of adjustment. The VECM has co-integration relations built into the specification so that it restricts the long run behavior of the endogenous variables to converge to their co integrating relationship, while allowing for short-run adjustment dynamics. The co-integration term is known as the error correction term (ECT). If there is any deviation from long-run equilibrium, it is

corrected gradually through a series of partial short-run adjustments. The dynamic specification of the VECM allows the deletion of the insignificant variables, while the error correction term is retained. The size of the ECT indicates the speed of adjustment of any disequilibrium towards the long-run equilibrium state.

4.3 Granger causality

The usual Granger (1969) causality test for inferring leads in spurious regression results if variables are not stationary at the same levels. After ensuring the stationarity of all variables and establishing the long run relationship among the variables included in the model of study, the Granger's pair wise causality test is applied to establish the direction of causality among these variables. The Granger causality test for the case of two variables Y_t and X_t involves the estimation of the following Vector Autoregressive (VAR) model:

$$y_t = a_1 + \sum_{i=1}^{n} \beta_i X_{t-1} + \sum_{j=1}^{n} \gamma_j Y_{t-j} + \varepsilon_{1t}$$

$$X_t = a_1 + \sum_{i=1}^{n} \theta_i X_{t-1} + \sum_{i=1}^{n} \delta_j Y_{t-j} + \varepsilon_{2t}$$

There will be four possible outcomes of Granger Causality test. The first expected outcome may be that both variables X and Y Granger cause each other. Which, we call bidirectional causality. The next possible outcome can be that one variable Granger cause other but not vice versa like, X Granger causes Y but Y does not Granger cause X. Similarly, Y Granger causes X but X does not Granger cause Y. This will be called unidirectional causality. The last possibility is that no variable (neither X nor Y) Granger cause each other.

Table 1 Augmented Dickey Fuller (ADF) test for unit root

(a)		
Variable at level	With intercept and trend	P value
lgdp	−0.810	0.955
lcap	−1.492	0.815
llab	−1.808	0.682
lfhc	−1.761	0.703
lmhc	−1.592	0.775
(b)		
Variable at first difference	With intercept and trend	P value
Δlgdp	−4.862[a]	0.001
Δlcap	−4.220[a]	0.009
Δllab	−6.662[a]	0.000
Δlfhc	−9.221[a]	0.000
Δlmhc	−9.604[a]	0.000

[a] Rejection of null hypothesis of non-stationary at 5 % significance level

5 Empirical results

Before analyzing the long and short run dynamics, the unit root test is applied to ensure the stationarity of data and investigate the order of integration. The study is then, proceeded further for co-integration and causality tests.

5.1 Order of integration

ADF unit root test is employed to check the stationarity of logarithmic form of GDP (lgdp), CAP (lcap), LAB (llab), Fhc (lfhc) and Mhc (lmhc) at level as well as at the first difference. Results with respect to intercept and trend are given in Table 1.

As per results given in Table 1(a), the p values of all series are statistically insignificant and cannot reject the null hypothesis of non-stationarity at 5 % level of confidence. It indicates that all variables are non-stationary at level and these variables have unit root problem. The ADF test is than applied at first difference of each variable. Results are given in Table 1(b). The null hypothesis of non-stationary series is rejected at first difference. Therefore, the higher order of integration is not required since log of all variables are stationary at first order of integration I (1). The multivariate co-integration test for long run analysis can now be applied.

5.2 Optimal Lag length

As per Table 2 all, Akaike Information Criteria, Schwarz Information Criteria and Hannan-Quinn Information suggest optimal log length of 1. Thus the lag length 1 is used in this study.

5.3 Empirical results for long run and short run dynamics

5.3.1 Long run dynamics

Johansen co-integration is applied to check the long run dynamics between economic growth, physical capital, labor force, female human capital and male human capital. The results of the Johansen co-integration test by using the λ trace statistics are given in Table 3.

The results of Johansen's co-integration based on λ_{trace} given above in Table 3 is used to test the co-integration vector hypothesis from no co-integration vector to higher co-integration vectors. As per result, Trace statistics value have reported three co-integrating vectors and have rejected null hypothesis no co-integration $(r = 0)$, at most one co-

Table 2 VAR lag order selection criteria

Lag	FPE	AIC	SC	HQ
0	1.23e-09	−6.32553	−6.11251	−6.24901
1	4.06e-4[a]	−16.6577[a]	−15.3781[a]	−16.19867[a]

FPE final prediction error, *AIC* Akaike information criterion, *SC* Schwartz information criterion, *HQ* hannan-quinn information criterion

[a] Denotes lag order by the criterion

Table 3 Unrestricted co-integration rank test (trace)

Hypothesis H_0	Alt. hypothesis H_1	Trace statistics	0.05 Critical value	Probability[b]
$r = 0$[a]	$r \geq 1$	130.777	69.818	0.0000
$r \leq 1$[a]	$r \geq 2$	59.960	47.856	0.0025
$r \leq 2$[a]	$r \geq 3$	30.415	29.797	0.0424
$r \leq 3$	$r \geq 4$	8.979	15.495	0.3672
$r \leq 4$	$r \geq 5$	0.046	3.841	0.8299

Trace test indicates 3 co-integrating eqn.(s) at the 0.05 level

[a] Denotes rejection of the hypothesis at the 0.05 level

[b] MacKinnon-Haug-Michelis (1999) p-values

Table 4 Unrestricted co-integration rank test (max. Eigen value)

Hypothesis H_0	Alt. hypothesis H_1	Max. Eigen statistic	0.05 Critical value	Prob.[b]
$r = 0$[a]	$r = 1$	70.816	33.877	0.0000
$r \leq 1$[a]	$r = 2$	29.545	27.584	0.0277
$r \leq 2$[a]	$r = 3$	21.435	21.131	0.0453
$r \leq 3$	$r = 4$	8.938	14.264	0.2917
$r \leq 4$	$r = 5$	0.046	3.841	0.8299

Max-Eigen value test indicates 3 co-integrating eqn.(s) at 0.05 level

[a] Denotes rejection of the hypothesis at the 0.05 level

[b] MacKinnon-Haug-Michelis (1999) p-values

integration $(r \leq 1)$ and at most two co-integration $(r \leq 2)$ against the alternative that $(r \geq 1)$, $(r \geq 2)$ and $(r \geq 3)$ because test statistics of trace are greater than critical values at 5 % significance level.

Thus the analysis of data confirms the presence of three co-integrating vectors and it can be concluded that the long run relationship exists between economic growth, physical capital, labor force, female and male human capital.

The results of Johansen's co integration based on $\lambda_{\text{max.eign}}$ given above in Table 4 is used to test the co-integration vector hypothesis from no co-integration vector to higher co-integration vectors. As per result Maximum Eigen value have also reported three co-integrating vectors and have rejected null hypothesis of no co-integration $(r = 0)$, at most one co-integration $(r = 1)$ and at most two co-integration $(r = 2)$ against the alternative that co-integration is equal $(r = 1)$, $(r = 2)$ and $(r = 3)$ because test statistics of max. Eigen values are greater than critical values at 5 % significance level.

Thus the analysis of data confirms the presence of three co-integration vectors and we can conclude that the long run relationship exists between economic growth, physical capital, labor force, female and male human capital.

As the co-integration exists between the variables under consideration, thus the results obtained from OLS, reported in Table 5 are reliable. To remove the problem of auto correlation AR(1) the Cochrane test approach has been applied. The result indicates that female human capital is statistically significant and has positive impact on economic growth. The estimates represent that on average 1 % rise in female human capital brings

Table 5 Long run relationship dependent variable LGDP

	Coefficient	t-statistics	Prob.
C	7.464768	7.135265	0.0000
lcap	0.325870	4.541037	0.0001
llab	0.923998	8.793186	0.0000
lfhc	0.216622	2.625741	0.0130
lmhc	0.046665	1.368120	0.1805
AR(1)	0.502956	5.696728	0.0000

F-Statistics = 238.4110
Prob.(F-Statistic) = 0.0000
$R^2 = 0.9972$
Adjusted $R^2 = 0.9968$

Table 6 Results of ECM for short run dynamics

Variables	Coefficient	t-statistic	Prob. value
C	0.0332	3.0894	0.0045
Δlgdp(−1)	0.4174	2.0267	0.0523
Δlcap	0.1445	2.4262	0.0220
Δlcap(−1)	−0.1021	−1.4969	0.1456
Δllab(−1)	−0.1760	−0.7452	0.4623
Δlfhc	0.0318	0.4694	0.6424
Δlfhc(−2)	−0.0502	−1.8635	0.0729
Δlmhc	0.0159	0.7877	0.4375
ECT(−1)	−0.3964	−2.1778	0.0380

$R^2 = 0.3838$
Adjusted $R^2 = 0.2077$
F-statistic = 2.1801
Prob.(F-statistic) = 0.060

0.21 % rise in economic growth. Similarly physical capital and labor force are statistically significant and 1 % increase in physical capital as well as in labor force raise 0.33 and 0.92 % economic growth respectively. Whereas, male human capital is statistically insignificant but has a positive impact on economic growth. The estimates indicate that 1 % increase in male human capital brings only 0.05 percent rise in economic growth.

5.3.2 Short run dynamics

The Least Square estimation is used under specification of Error Correction Model (ECM), for short run dynamics of long run equilibrium between economic growth, physical capital, labor force, female human capital and male human capital. The preferred Parsimonious result is given in Table 6.

In the ECM Specification, the coefficient of lag error correction term $\left(ECT_{(t-1)}\right)$ is significant and carries the negative sign. The negative sign of coefficient of $ECT_{(t-1)}$ indicates the convergence of short run disequilibrium to long run equilibrium. While the value of coefficient shows the speed of adjustment toward the long run equilibrium. The significant coefficient of $ECT_{(t-1)}$ suggests that on average there is 39.6 percent adjustment in the current period (t) to the disequilibrium in the previous period $(t-1)$.

The coefficient of physical capital is positive and significant while the coefficients of female human capital and male human capital are positive but insignificant. It implies that on average 1 percent increase in physical capital leads 0.14 % increase in economic growth while I percent increase in female human capital and male human capital bring 0.032 and 0.016 % rise in economic growth respectively. Similarly one year lagged economic growth also has a positive and significant impact on economic growth.

Table 7 Diagnostic tests

Tests	F statistics	Probability
Jarque–Bera test (normality test)	3.1560	0.2064
Breusch – Godfrey test (serial correlation)	2.3231	0.1373
White test (Hetroskadesticity)	1.8797	0.1008
Ramsey RESET test (model specification)	0.4906	0.9760
ARCH test (auto regressive)	0.0009	0.97601

5.4 Diagnostic tests

Diagnostic tests have under taken to check the consistency of the estimation of short run model with the standard assumptions of OLS. The results are reported in Table 7.

The Jerque Bera test for normality does not reject the null hypothesis of errors, as the test statistics is not significant and indicating that the residuals from parsimonious short run are normally distributed. The estimates of Breusch–Godfrey also confirms that there is no significant evidence of the serial correlation in residual of short run model. The white test of hetroskedasticity rejects the presence of hetroskedasticity in short run model by not rejecting the null hypothesis of error that there is no evidence of hetroskedasticity. The Ramsey's RESET test's results have suggested that the model specification is quite appropriate and the parameters of the model are stable. This is a general test for omitted variables and to test the viability of functional form of the model. ARCH test statistics confirm that there exists no autoregressive conditional hetroskedasticity in residual.

5.5 Granger's pair wise causality

After ensuring the long run relationship among the variables under consideration of this study, the Granger's pair wise causality test is applied to establish the direction of causality among these variables. The Granger causality test examines the direction of causality among two variables. The results of Granger causality test are reported in Table 8.

Table 8 Granger pair wise causality test

Null hypothesis	F-statistics	Probability
lfhc does not granger cause lgdp	0.3232	0.7260
lgdp does not granger cause lfhc	22.023	8.4E−07
lmhc does not granger cause lgdp	0.5080	0.6062
lgdp does not granger cause lmhc	16.7075	8.8E−06
lfhc does not granger cause lcap	3.0656	0.0600
lcap does not granger cause lfhc	9.9669	0.0004
lmhc does not granger cause lcap	2.5716	0.0912
lcap does not granger cause lmhc	13.3990	5.1E−05
lfhc does not granger cause llab	0.0599	0.9419
llab does not granger cause lfhc	4.5087	0.0186
lmhc does not granger cause llab	0.3076	0.7372
llab does not granger cause lmhc	8.4216	0.0012
lfhc does not granger cause lmhc	9.2156	0.0483
lmhc does not granger cause lfhc	3.3269	0.0007

Results indicate that unidirectional causality exists between female human capital (lfhc) and male human capital (lmhc) with economic growth (lgdp). It implies that any improvement in economic growth will cause betterment in female and male human capital. While improved female and male human capital do not granger cause economic growth. Similarly fixed capital investment and labor force both have positive and significant relationship with female human capital and male human capital. So policies to encourage fixed capital investment will bring improvement in female and male human capital. While improved female and male human capital do not encourage labor force but encourage fixed capital investment and do marginally Granger Cause fixed capital investment. However, female human capital and male human capital have bidirectional causality.

6 Conclusion and policy recommendations

6.1 Summary and conclusion

The study has been conducted to provide empirical evidence concerning the short run and long run dynamics of female human capital and economic growth. For this purpose, data on gender specific human capital along with labor force, physical capital and male human capital as inputs have been used to empirically test the female human capital's contribution in economic growth of Pakistan.

Pakistan is a developing economy. Its economic growth rate has been low and inconsistent. Female segment has been neglected in the society and been denied fair access to social and economic opportunities. They are mostly deprived of acquiring education and skill. Their health status has also kept their efficiency low. Pakistan's gender inequality indices show extreme gender discrimination with respect to health, education and economic opportunities.

In Pakistan, Public Policies regarding education and health have not been very successful to achieve the desired targets due to poor planning, bad governance and defected implication. Budget allocation, have also been extremely meager resulting very little contribution in forming human capital.

Relevant literature on the subject examined in this study has supported the positive contribution for gender neutral human capital in economic growth. However, in respect of female human capital the literature is not supportive enough and been controversial. Generally education and partially health indices have been used as proxies for human capital.

The methodology used for long run dynamics of female human capital on economic growth of Pakistan is Johanson's co-integration and parsimonious Error Correction Model for short run dynamics. The Granger's pair wise causality test is used to test the nature of causality among the variables used in this study.

The unit root test based on ADF indicates that all the variables included in model are non-stationary at level and have become stationary at their first difference. The variables are therefore, integrated of same order 1(1) Johanson co-integration test indicates that the long run relationship exists among the variables included in the model. Female human capital is significant and positively related to economic growth. While male human capital, is insignificant and positively related to economic growth. The results of this study are therefore, consistent with the findings of Caselli et al. (1996) and have not supported the Barro and Lee (1994)'s finding that female human capital is insignificant and negatively related to economic growth. Result shows that both male and female human capital's contribution in economic growth is positive. However, female human capital's role is

significant but in case of male human capital it is insignificant. It can be justified by female human capital's multivariate roles in a society compare to male human capital. As Caselli et al. (1996) has also supported his argument for positive and significant role of female human capital by its strong relationship with fertility rate. Fall in fertility indirectly enhanced the role of female human capital and made it more significant compare to male human capital in economic growth. There is no such theory which is consistent regarding sign and significance of role of gender specific human capital in economic growth. In this regard, different models with different proxies for human capital predict different signs and significance levels of male and female human capital in economic growth.

The results of short run dynamics of ECM have suggested that female human capital is a long run phenomenon. It is positively related to economic growth but insignificant in short run. The results of Granger's pair wise causality indicates that unidirectional causality exists between economic growth and female human capital. Only economic growth Granger cause female human capital. While, female human capital does not Granger cause economic growth. These findings are not parallel to the Johanson co-integration test results stated in preceding para. It implies that female human capital has positive and significant relationship with economic growth in a model along with other variables. Whereas, Granger's pair wise causality test establishes only the relationship between subject pair and does not take into account, rest of the variables in a model. The Granger's causality test results indicate that female human capital has no direct influence on economic growth. This result has further strengthened the argument of Caselli et al. (1996) regarding the indirect role of female human capital in economic growth.

However, the poor role of specifically male (direct as well indirect) and partially female human capital (only direct) can be justified by an argument that in general human capital has not been reached at a thrash hold level to directly boost the economic growth. The quality and quantity of human capital may also not be substantial enough, to influence economic growth directly. However, female segment of the society due to its multivariate role has emerged comparatively significant in long run economic growth.

6.2 Policy implications

Suggestions regarding policy implication are based on above findings and conclusions that female human capital has positive and significant, while male human capital has positive but insignificant long run relationship with economic growth. Whereas male and female human capital, both are insignificant regarding pairwise relationship with economic growth.

In Pakistan there is no uniform education system at school, college and university level. Different systems prevail for different economic classes of the society. There is an English medium, Urdu medium and Madras's for religious teaching. Apart from uniformity in education, quality of education rendered by mushroom of private and public educational institutes is not compatible with international standard. Moreover, knowledge gap (knowledge required and education provided) may also restrict the male and female human capital to be more effective and productive in economic growth.

Similarly, In Pakistan there is also no uniformity regarding provision of health facilities. Public health facilities have been deteriorating over time and private health facilities are unaffordable for the middle and lower income group. Though, life expectancy has improved over the years but the required efficiency has not been achieved to enhance the economic growth.

In this regard it is suggested to make the human capital more effective through uniform education system applicable all over the Pakistan without any regional, social, ethnic and

gender discrimination. All the educational and health institutions must have to maintain a certain criteria regarding the quality of education and health to meet the challenges. Moreover the elimination of the knowledge gap is also recommended to further enhance the role of male and female human capital in economic growth.

Social, economic and political empowerment of women is very important to make their role more effective (directly and indirectly) in economic growth. If females are empowered to make their decision independently they will be able to contribute more in social uplift of the society and the growth as well. Public policies therefor, should be in line to provide equitable employment opportunities to females. Guidance and counseling services should be made available to acquaint female labor force on the range of jobs for which they can apply and the skill required for opportunities available in the market. There should also be complete elimination of gender discrimination in remunerations to female workforce.

Moreover, this study has concluded that the formation of human capital relies on long term planning and it is not a short term phenomena. Thus a comprehensive long term planning is required through policies and legislation such as compulsory primary education.

6.3 Further area of research

This study has opened further areas of research such as:

Regional disparities prevail in developing societies. So the role of female human capital in economic growth can be extended to regional level. In this regard, regional ranking of female human capital index can be constructed to identify the areas or regions, where female human resource is not up to the mark and not contributing much for the social and economic uplift of the area.

Education and health are the important components of human capital. In this study, we have used both education and health as a composite gender separate human capital to identify their role in economic growth. The study can also be extended to use the model based on health and education as a separate explanatory variables to quantify their independent role in economic growth of the country.

Different authors have used different proxies for human capital according to their interests and availability of data. No uniformity is therefore, in their outcomes and results. The study can also be extended to make a comparison of different proxies and their respective outcomes. It can help to analyze the most appropriate proxy for human capital regarding its influence on economic growth of a country.

Appendix A

Human capital (H)

$$\text{Female human capital} = \text{Female education index} + \text{Female health index}/2$$

$$\text{Male human capital} = \text{Male education index} + \text{Male health index}/2$$

Education index (female and male)

According to the Pakistani education system, the number of enrolment at different levels of schooling years are taken in five categories. First one is the primary level consist at five years of schooling, second for middle stage consist at eight years of schooling. Then

secondary and higher secondary consist on ten and twelve years of schooling respectively. Professional and university level of education cover sixteen years of education. The following formula has been used to construct a weighted education for male and female separately.

$$\text{W. Education } = (5H_{1t} + 8H_{2t} + 10H_{3t} + 12H_{4t} + 16H_{5t})/POP_t$$

H_t stands for enrolment (female and male) at time t and POP for total population (female and male) at time t. Weighted Education is further standardized by taking maximum and minimum values observed as goalposts in order to transform the indicator into indices from 0 to 1.

Maximums are the highest observed values in the time series as it is used by UNDP in the construction of Human Development Index (HDI) (2006, 2011). While UNDP has conceived minimum values at some subsistence level (vary in dimensions of development and over the period). However in this study maximum and minimum values are observed values in time series to transform indices from 0 to 1.

$$\text{Education index } = \frac{\{(\text{actual} - \text{minimum})\ \text{W. Education}\}}{\{(\text{maximum} - \text{minimum})\ \text{W. Education}\}}$$

Health index (female and male)

Life expectancy is a proxy used for health. It is further standardized by taking maximum and minimum values (goalposts) in order to transform the indicators into indices from 0 to 1.

$$\text{Health index} = \left\{\frac{(\text{actual} - \text{minimum})\ \text{life expect}}{(\text{maximum} - \text{minimum})\ \text{life expect}}\right\}$$

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