

Human Capital and Growth: A Reassessment using new data

by

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Abstract

In this research paper, we study the impact of human capital on economic growth using Barro and Lee (2013) recent and updated dataset (June, 2014) of human capital variable in a fixed effect and dynamic panel model across 140 countries over the period of 1950 to 2010. Using a modification of Islam (1995) and Barro (2001) empirical framework in a Arellano and Bond (1991) dynamic panel model, we find significant positive impact of human capital on transitional economic growth where female educational attainment is positive and significant along with male education.

1.0 Introduction

In recent times, a key area of research interest of macroeconomics and international development is to study the link between human capital and economic growth. Measurement of human capital has been a concern of many studies, some use enrollment ratio, literacy ratio to measure human capital and some use years of schooling. Development of the longitudinal panel data sets on school attainment by Barro and Lee (1993) greatly facilitates research on human capital.

In this research paper, we use Barro and Lee (2013) recent and updated dataset (June, 2014) of human capital variable to study its impact on growth rate using fixed effect and dynamic panel model across 140 countries over 13 five year periods from 1950 to 2010. A modification of Islam (1995) and Barro (2001) empirical framework is followed where human capital is measured as stock (quantity of educational attainment).

This study contributes to the existing literature in two ways. First, it extends to more sample information and time span from 1950 to 2010 to study 140 countries' growth rate and educational attainment. Second, it uses Arellano-Bond Generalized Method of Moment (GMM) estimators in a dynamic panel model to correct endogeneity and serial correlation among the explanatory variables along with fixed effect model and compare the results.

We find that average educational attainment has positive and significant impact on transitional growth rate and has long term positive impact on GDP per capita, similar to Barro (2001). However, in Barro (2001), school attainment refers to male secondary and higher levels of educational attainment. We also study the impact of composition of the educational attainment on growth rate and find positive and significant impact of primary and secondary schooling on growth rate, where post-secondary education lacks significant explanatory power. This study also confirms conditional convergence among countries. We also find female educational

attainment has a more significant impact than male. This result is consistent with Coulombe, Tremblay, & Marchand (2004).

The remainder of the paper is constructed as follows. Section 2 describes the existing literature on growth and human capital. Section 3 explains the empirical methodology, methodological approach and describes the data and the econometric model. Section 4 explains the result of fixed effect and dynamic panel model. Section 5 concludes this research.

2.0 Literature Review

There has been considerable empirical and theoretical research to study the determinants of economic growth. Growth accounting is one of the earliest attempts to determine how much growth can be explained by increase in three components: growth in labor input, growth in total factor productivity and growth in capital input. This accounting can be performed for any country with relevant data on output and inputs, but not across country comparisons (Parker, 2012). In the 1960s, growth theory was more concentrated on the neoclassical growth model, pioneered by Ramsey (1928), Solow (1956), Swan (1965) and Cass (1965), and Koopmans (1965). Solow-Swan growth theory emphasized that the steady-state rate of growth of any economy is a function of technological accumulation where growth is driven by improvement of productivity via technological progress, determined exogenously.

To make international comparisons of income or growth across countries, some important and appealing implications, particularly convergence theory of the Solow model could not be tested due to lack of reliable data until the 1980s. With the development of internationally comparable data on income and price levels (Penn World Table) by Summers and Heston (1991), research on neoclassical convergence hypothesis has been spurred and seriously exploited by Barro (1992); Mankiw, Romer, & Weil (1992); Barro & Sala-i-Martin (1995).

Researchers find that poor economies tend to grow faster than richer ones if all economies are homogenous. This is called *Absolute convergence*. However, if economies are heterogeneous (differ in various aspects, such as propensities to save, access to technology, willingness to work etc.), then the convergence hypothesis applies only in a conditional sense. In the neoclassical model, steady state level of capital and output per worker depend on the propensity to save, population growth and the position of the production function. This means the convergence is conditional among heterogeneous countries (Barro, 1997). The *Conditional convergence* hypothesis stipulates that an economy grows faster if the starting per capita GDP is low relatively to its own long run steady-state level. This convergence property derives from diminishing returns to capital which suggests that an economy with higher level of per capita capital relative to long-run capital per worker tends to grow slowly as returns to capital are low (Barro, 1997). Recent empirical studies indicate that we should include additional sources of cross-country variation, especially differences in government policies and in initial stock of human capital.

Another approach to study growth theory is the endogenous growth model, developed by Romer (1986) and Lucas (1988), in which long term growth is determined by government policies and other factors of the economy. Capital is broadened to include human capital components and allow spillover effects and considers absence of diminishing returns that suggested growth indefinitely with accumulation of capital, but the rates of growth and investment might not be pareto optimal (Barro, 1997). According to Barro (1997), endogenous growth theories that include discovery of new ideas and production methods play a more important role to predict long term growth and to provide possible explanations. However, the older neoclassical model, extended to include government policies, human capital, and the diffusion of technology gives more inspiration and support to recent cross-country empirical studies, from a qualitative perspective as synthesized in Barro and Sala-i-Martin (1995) (Barro,

1997; Coulombe, Tremblay, & Marchand, 2004). Mankiw, Romer, & Weil (1992) have extended the concept of capital and modified the basic Solow model to allow accumulation of human capital. With cross-country regressions, they confirmed conditional convergence theory. Since then, this concept of conditional convergence theory has been many times confirmed by cross-country and panel data analysis (Barro 1997; Coulombe, Tremblay, & Marchand, 2004). Barro (1997) also explains that theories that include basic technological change may be more important to understand why the world as a whole in per capita terms will grow indefinitely rather than explaining the determinants of relative growth across countries.

2.1 Human Capital and Economic Growth

The role of human capital on economic growth has emerged as a key area of research interest. Research on human capital has been greatly facilitated by the development of the longitudinal panel data sets on school attainment (Barro & Lee, 1993). The concept of human capital has received considerable attention in both endogenous growth and growth empirical approaches. Evidence suggests that higher level of schooling, training and other forms of human capital increase individuals' earnings significantly and can be seen as a possible route to escape poverty (Barro, Caselli, & Lee, 2013).

Barro and Lee (1994) is among the first who incorporate human capital as an explanatory variable in a growth regression. However, it is not straightforward to measure human capital and many macroeconomic studies acknowledged the human capital measurement issue as an obstacle to study its impact on economic growth (Parker, 2012; Coulombe, Tremblay, & Marchand, 2004; Hanushek, 2013). School enrollment data is available from international agencies (UNESCO), national governments and census data. But, school enrollment ratio captures the flow of education (investment in human capital), not the stock of capital. The Barro and Lee data set (1993, 2013) has overcome this problem as it measures "educational

attainment” as a stock of human capital (Parker, 2012, Barro, 2013). Mincer (1970) emphasizes that development of the general skills of individuals was the primary motivation for schooling, therefore, it makes sense to measure human capital by the amount of schooling completed by individuals (Hanushek, 2013). Elmawazini, Atallah, Nwankwo, & Dissou (2013) argue that Human Development Index (HDI) is a better measure of human capital than average years of schooling as HDI index accounts for education, health and income. However, to examine the effect of human capital on growth, school attainment might be better in growth regressions than HDI index to avoid multicollinearity with GDP per capita.

Barro (1997) introduces an empirical framework that follows the extended neoclassical growth model of Solow (1956) where labor productivity growth in the long run is solely determined by technological progress. The study models growth rate of per capita output (Dy) as a function of current level of per capita output (y) and the long run or steady state level of per capita output (y^*) where the growth rate of per capita output is inversely related with y for given determinants of y^* and for given y , the growth rate increases with y^* . y^* depends on various choice and environmental variables such as government policies, household behavior with respect to savings, fertility, etc. According to Barro (1997), for a given level of per capita output (y), an increase in the steady-state level (y^*) raises the per capita growth rate over a transition period. Barro (2001) mentions that “ y would be generalized to encompass the levels of physical and human capital” (12) and “... Given the level of GDP, a higher initial stock of human capital signifies a higher ratio of human to physical capital. This higher ratio tends to generate higher growth...” (14).

Growth effects from changes in choice and environmental variables tend to persist for a long time as the transition period tends to be lengthy (Barro, 1997). Coulombe, Tremblay, & Marchand, (2004) also point out that “... in a neoclassical growth framework, as long as the convergence speed is positive, variables like fertility, literacy (human capital), or investment rate

will only affect the level of long run GDP per capita or labor productivity; the steady state growth rate being determined solely by the growth rate of technological progress” (16). They also mention that with slow convergence speed in growth regression (2%-6%), it takes a long time to reach new steady state after a shock. The transitory effect of human capital shock on GDP per capita or labor productivity can be lengthy (may need 35 and 11.5 years to meet 50% of the gap to reach the new steady state at 2% and 6% convergence speed respectively). Parker (2012) argues that Barro and Lee’s results suggest a higher stock of human capital leads to higher productivity growth, as educated workers perhaps are better able to adopt new technologies. Barro (2001) emphasizes that human capital, measured by educational achievement, appears to have a significant positive long run level effect on GDP and a transitory positive effect on growth towards the steady state (Coulombe, Tremblay, & Marchand, 2004). Higher initial level of human capital increases the ratio of human capital to physical capital for given level of GDP, and this tends to increase growth through absorption of superior technologies and also due to the fact that physical capital is more easily controlled than human capital (Barro, 1997, 2001). Also, Cohen and Soto (2007) confirm the growth effect of increased schooling.

Barro (2001) studies panel estimations for roughly 100 countries from 1960 to 1995 over three ten year periods using the Barro and Lee (2001) human capital data set. The dependent variable is the growth rate of real per capita GDP for each of the periods: 1965-1975, 1975-1985 and 1985-1995. The explanatory variables are real GDP per capita, male schooling (years of attainment of the population aged 25 and over at the secondary and higher levels) in 1965, 1975 and 1985; life expectancy at birth for 1960-64, 1970-74, and 1980-84; government consumption ratio, measured exclusively on education and defense; the openness ratio which is a ratio of exports and imports to GDP; an interaction variable $\text{openness} \cdot \log(\text{GDP})$, which is the openness ratio multiplied by the log of GDP per capita at the start of the period; a rule-of-law index that applies to the early 1980s (one observation for each country) ; a terms of trade

variable taken as the growth rate over each period of the ratio of export to import prices; the inflation rate computed as the growth rate over each period of a consumer price index or as the GDP deflator. The other variables are the log of the total fertility rate and the ratio of investment to GDP ratio.

According to Barro (2001), the estimation procedure overcomes the endogeneity problem that arises when many determinants of economic growth are considered in the regression by using three-stage least squares (with different instrumental variables used for each equation) (Barro, 1997; Barro, 2001). The instruments include the five year earlier value of log (GDP) (for example, for 1960 in the 1965-1975 equation); the actual level of schooling, the openness ratio and the terms of trade variables and lagged value of other variables. In a previous study, Barro (1991), use a cross-sectional framework where the growth rate and the explanatory variable are observed only once per country. The rationale to extend to panel set up is to extend the sample information, but he finds more evidence from cross-sectional (between-country) variation rather than the time series (within-country).

Barro (2001) finds significant positive effect on growth from the years of schooling at the secondary and higher levels for males aged 25 and over for 100 countries taken together. An extra year of male upper-level schooling is therefore estimated to raise the growth rate by a substantial 0.44 percentage point per year. According to Barro (2001), male primary schooling for persons aged 25 and above has also an insignificant effect if added to the system which suggests male higher education predicts growth, but not primary education. However, female education at various levels appeared to have no significant effect on growth, the estimated coefficient is -0.0011 (0.0040). In the earlier results, Barro and Lee (1994) find that the estimated coefficient on female secondary and higher schooling was significantly negative, it becomes essentially zero with revised data on education. According to Barro and Lee (1994) and Schultz (1989), female education has a strong negative relation with the fertility rate and fertility rate is

negatively related with growth rate, therefore, female education may increase economic growth through this indirect channel, by lowering fertility.

Coulombe, Tremblay, & Marchand (2004) study the relationship between human capital and growth across 14 OECD countries, where human capital is measured based on literacy scores, collected from the International Adult Literacy Survey (IALS). The study finds positive and significant effect of the literacy rate on long run GDP level and labor productivity and growth rate in the transitory process towards steady state. It also finds that human capital indicators based on the average literacy scores per country perform better than indicators based on the percentage of the population which has achieved top scores. Another important finding of their study is that the effect of female literacy rate on growth outperforms the effects measured from indicators based on male literacy, even after controlling for fertility rate and relative female/male labor market participation rate. However, some researchers argue that enrollment or literacy rate as a measure of human capital might show the flow of education rather than the stock of human capital (educated people) (Parker, 2012; Barro, 2013).

Fleisher, Li, & Zhao (2010) investigate the impact of regional differences in physical, human, and infrastructural capital as well as differences in foreign direct investment (FDI) flows on regional growth patterns in China. The study finds that human capital (measured as enrollment ratio) has a positive impact on growth and affect output in three ways: an educated labor force contributes to increased production, human capital (measured by the proportion of workers with some senior high school education or above) has a positive and direct effect and has an indirect spillover effect on TFP growth. It concludes that positive impacts of education are more consistent than those found in cross-national studies.

However, Islam (1995) found no significant relationship with human capital in the growth regression using panel data approach, even gets negative sign for all samples. The study includes fixed time-invariant effect and human capital variable (HUMAN) from Barro and Lee's (1993) dataset which provides information about the average years of schooling. One of the

potential problems of the study is serial correlation among the explanatory variables which results in serial correlation in the disturbance (Coulombe, Tremblay, & Marchand, 2004).

Cohen and Soto (2007) mention some potential problems in the Barro and Lee (1993) data set and present a new data set on years of schooling across countries for the 1960-2000 period and finds significant coefficient for schooling in a standard cross-country growth regression. The study shows a table which summarizes the main results of macro studies which are based on income growth from Summers and Heston (1991) and Barro and Lee (1993) data on years of schooling. The table shows the regression results of Benhabib & Spiegel (1994) who find non-significant and negative relationship for the log of years of schooling. Another study Pritchett (2001) also gets non-significant and negative coefficient for human capital. Cohen and Soto (2007) also mention a study by Krueger & Lindahl (2001) who get positive, but non-significant effect of the change in the level of schooling on the log change of income.

There are some recent studies which concentrate on the impact of composition of human capital on economic development. Ramcharan (2004) confirms a positive relationship between human capital and economic development, and argues that composition of human capital, not its level, determines the long run steady state of economic development. Using an analytical framework, the study examines which level of education (secondary or tertiary or so on) has greater impact on economic growth. Assuming each skill type performs a specific but complementary function within the production process and endogenous schooling costs, the study concludes that initial investment in both types of schooling (secondary and tertiary) should be the heaviest, and investment should be made in both types of schooling.

A more recent study by Zhang & Zhuang (2011) examines the effect of the composition of human capital on economic growth in China using dynamic panel data method (Generalized Method of Moments (GMM)) over 1997-2006. They find that tertiary education plays a more important role on economic development than primary and secondary education in China.

Another recent study by Campbell & Agbiokoro (2014) examines the role of government investment on human capital on economic growth of Nigeria from 1980-2010 using OLS and three-stage least square approaches following the Augmented Human Capital Solow model. It concludes that human capital alongside with technological development and population growth have a positive relationship with growth of the Nigerian economy and emphasizes that an adequately trained and employed population enhances the growth of the economy. It also mentions that higher education is a prerequisite for the production of highly competent experts, which in turn, contributes to the development of organizations and the economy at large.

2.1.1 Quality of Education and Economic Growth

Recently, researchers also incorporate quality of education in the growth regression and argue that the quality of schooling is more important than its quantity. Hanushek and Kimko (2000) find that scores on international examinations, which is an indicator of quality of schooling, has a larger impact than years of attainment on subsequent growth. Hanushek (2013) mentions that differences in economic growth across countries are closely related to cognitive skills as measured by achievement on international assessments of mathematics and science. The study emphasizes that school attainment has no independent impact on growth if cognitive skills are constant in empirical growth models. Using the same dataset as Hanushek and Kimko (2000), Barro (2001) incorporates information on student test scores in science, mathematics and reading for 43 countries to measure the quality of schooling. He finds that scores on science tests have a particularly strong positive relation with growth. Given the quality of education, measured by international test scores, quantity of education, measured by average years of schooling attainment of adult males at the secondary and higher levels has a positive impact on the growth rate of the economy. The study also argues that the effect of school quality is quantitatively larger and more important for growth than average years of school attainment of adult males at the secondary and higher levels.

2.1.2 Development Accounting: Quantity of Schooling and Living Standards

In recent years, there has been a new research interest to study the impact of quantity of schooling in the living standard in developed and developing economies. There has been significant improvement in school attainment across developing countries (Hanushek, 2013). In developing countries, average years of schooling for the population aged 15 years and over increased significantly from ~2 to 7.2 years since 1950 (Barro, Caselli, & Lee, 2013). But the gap between developed and developing countries has decreased slightly by 1 year in the past 40 years. Barro, Caselli, & Lee (2013) mention that these interesting findings motivate the paper by Caselli & Ciccone (2012) who study Development Accounting to answer the question "How much of the cross-country income variance can be accounted for by differences in the quantity of schooling?" (181). Development accounting predicts a robust result that a small fraction of the output gap between developing and rich countries can be explained by the difference of quantity of schooling. However, according to Barro, Caselli, & Lee (2013) this development accounting derives from a parametric approach where perfect substitutability among schooling level and skill neutral technology differences are assumed skill-neutral, where empirical evidence rejects perfect substitutability among schooling levels.

3.0 Empirical Methodology

3.1 The panel data model

Following Islam (1995) and many subsequent studies, we pool time series and cross-country information in a panel data approach across 140 countries to study the impact of human capital in the convergence-growth relation. The panel approach in growth regressions allows to control individual "country effects" and exploits information contained in the time series. It corrects for the bias occurring due to country specific aspects which are correlated with explanatory variables in cross-sectional studies (Coulombe, Tremblay, & Marchand, 2004). Islam (1995)

was the first in implementing panel formulation of the human capital augmented Solow production function approach using the Mankiw-Romer-Weil (1992) (M-R-W after wards) model and allow for country fixed effects to correct for the omitted variable bias. Islam (1995) shows that improvements in the country fixed effects may also lead to higher transitional growth rate.

3.1.1 Methodological Approach

The theory can be illustrated using the Solow-Swan model with labor augmenting production function. Islam (1995) derives a growth regression equation and includes human capital in the regression in a panel data model. The study reformulates the growth equation based on M-R-W estimation by moving from a single cross-section for several shorter periods in terms of income per capita.

$$\ln y(t_2) = (1 - e^{-\lambda\tau}) \frac{\alpha}{1-\alpha} \ln(s) - (1 - e^{-\lambda\tau}) \frac{\alpha}{1-\alpha} \ln(n + g + \delta) + (e^{-\lambda\tau}) \ln y(t_1) + (1 - e^{-\lambda\tau}) \ln A(0) + g(t_2 - e^{-\lambda\tau} t_1) + \varepsilon_{it} \quad (1)$$

Here, it follows Solow-Swan labor augmented Cobb-Douglas production function, where y is output per effective worker, s represents exogenous growth rate of savings, n is exogenous growth rate of labor, g is exogenous growth rate of technology and δ is the rate of capital depreciation.

Islam (1995) shows this equation (1) represents a dynamic panel data model where $(1 - e^{-\lambda\tau}) \ln A(0)$ is the time-invariant individual country fixed effect term. The restricted form of the regression including human capital of this study is as follows:

$$\ln y(t_2) = (1 - e^{-\lambda\tau}) \frac{\varphi}{1-\alpha} \ln(h^*) + (1 - e^{-\lambda\tau}) \frac{\alpha}{1-\alpha} \ln(s) - (1 - e^{-\lambda\tau}) \frac{\alpha}{1-\alpha} \ln(n + g + \delta) + (e^{-\lambda\tau}) \ln y(t_1) + (1 - e^{-\lambda\tau}) \ln A(0) + g(t_2 - e^{-\lambda\tau} t_1) + \varepsilon_{it} \quad (2)$$

As mentioned earlier, Islam (1995) used Barro and Lee's (1993) HUMAN variable which gives information about the average years of schooling in total population over age 25 at all levels-

primary, secondary and higher. It gives a direct measure of the stock of human capital, and it appears as a stock in the equation.

In the above equation (2), h^* is the steady state of human capital and φ is the exponent of the human capital variable in the augmented production of M-R-W. As the equation (2) holds at any time, it can be rewritten by subtracting one period lag $\ln y_{it-1}$, from both sides.

$$\ln y_{it} - \ln y_{it-1} = (e^{-\lambda\tau} - 1) \ln y_{it-1} + \beta_1 \ln(h^*) + \beta_2 \ln(s) - \beta_3 \ln(n + g + \delta) + \mu_i + v_t + \varepsilon_{it} \quad (3)$$

Where, $\mu_i = (1 - e^{-\lambda\tau}) \ln A(0)$ represents the country-fixed effect term and $v_t = g(t_2 - e^{-\lambda\tau} t_1)$ represents the time-fixed effect term.

Barro and Sala-i-Martin (2004) show that other variables in the set of environmental variables can be added to the usual one implied by the simple augmented Solow growth model that might affect the production function. The study has proved successful in explaining long run cross country differences. Barro (2001) includes control variables- investment to GDP ratio, consumption to GDP ratio, population growth rate, openness ratio, rule of law index, etc. With a fixed effect approach, we cannot include time-invariant control variables such as rule-of-law indicator, democracy indicators or country size or geographical location (Coulombe, Tremblay, & Marchand, 2004). The key variable of interest in this study is human capital, measured as average years of educational attainment, showing the stock of human capital. Also, we control for government consumption, international openness along with investment ratio in the model.

Our benchmark panel data model is:

$$\ln y_{it} - \ln y_{it-1} = \lambda \ln y_{it-1} + \beta_1 \ln(h_{it-1}^*) + \beta_2 \ln(s_{it}) - \beta_3 \ln(g_{it}) + \beta_4 \ln(open_{it}) + \mu_i + v_t + \varepsilon_{it}$$

Where, g is the consumption to GDP ratio, s is the investment to GDP ratio, h^* is the steady state stock of human capital in the initial level of the period. More details of the econometric analysis and model are discussed in the “Econometric Analysis and Estimation Technique” section.

3.2 Data

Many subsequent studies acknowledge the difficulty to measure human capital in the growth empirics. In our model, we include the human capital variable in the model using Barro and Lee (2013) panel data set. The data set includes educational attainment across 146 countries from 1950 to 2010, disaggregated by sex and by 5 year age intervals for all levels-primary, secondary and tertiary educational attainments. This provides a more reasonable proxy for the stock of human capital for a broad group of countries than other measures, for example, school enrollment ratio or literacy rate, used in earlier empirical studies. Educational attainment measures the stock of human capital available contemporaneously as an input to production (Barro & Lee, 2013). The previous studies (Barro & Lee, 1993, 1996, and 2001) construct data sets on measuring educational attainment for ~100 countries from 1960 to 2000 and showed distribution of adult population over age 15 and over 25 at seven level of schooling for each country and for regions in the world. The recent study (2013) has extended previous estimates from 1950 to 2010 and expanded to 146 countries (24 advanced and 122 developing) and has improved the accuracy over previous data by incorporating recently available census/survey observations. Previously Barro (2001) has adopted a perpetual method, but was biased due to inaccuracy in estimated enrollment ratios. Enrollment ratio is used to estimate flows that are added to the stocks.

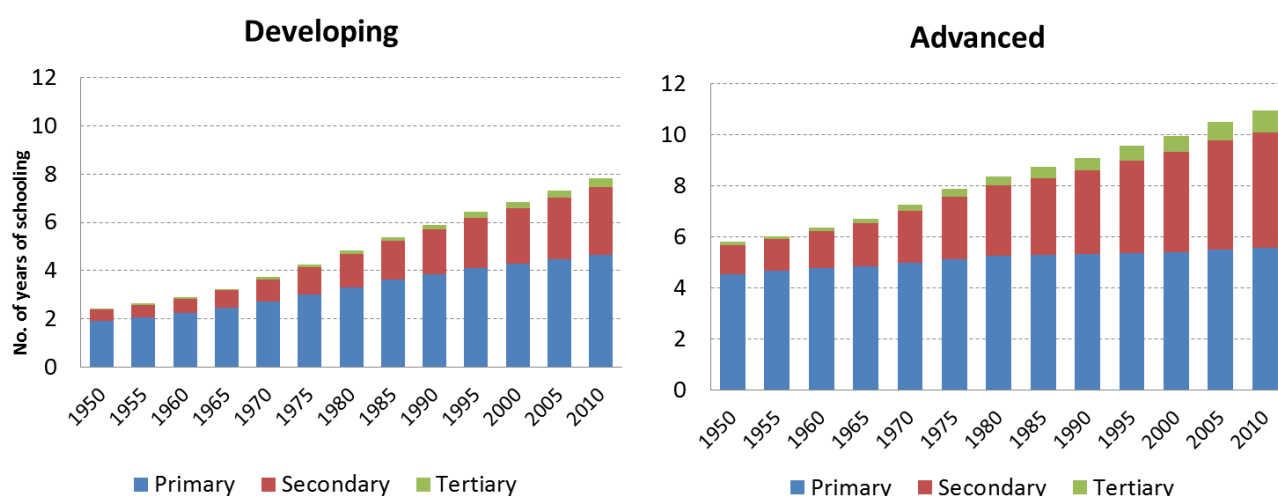
De La Fuente & Domenech (2006) and Cohen and Soto (2007) raise some concerns about the previous data set of Barro and Lee (1993). Barro and Lee (2013) claim that they have improved the new data set addressing those issues.

Studying Barro and Lee (2013) June, 2014 update, we see that world population aged over 15 years have on average 7.9 years of schooling, which has increased by 4.8 years from 1950.

Advanced economies have on average 11 years of schooling for population over age 15 years in 2010 compared with 7.8 years of schooling in developing countries (Fig.1).

In developing countries, average years of schooling has increased significantly from 2.4 years to 7.8 years where higher primary and secondary education have improved mostly than tertiary education. However, in advanced economies, improvements in higher secondary and tertiary education contributed mostly to higher average years of schooling over the period, while average years of primary schooling increased insignificantly.

Fig: 1 Average years of schooling by level of education for two broad groups of categories¹



Source: Adapted from Barro and Lee (2013) data set

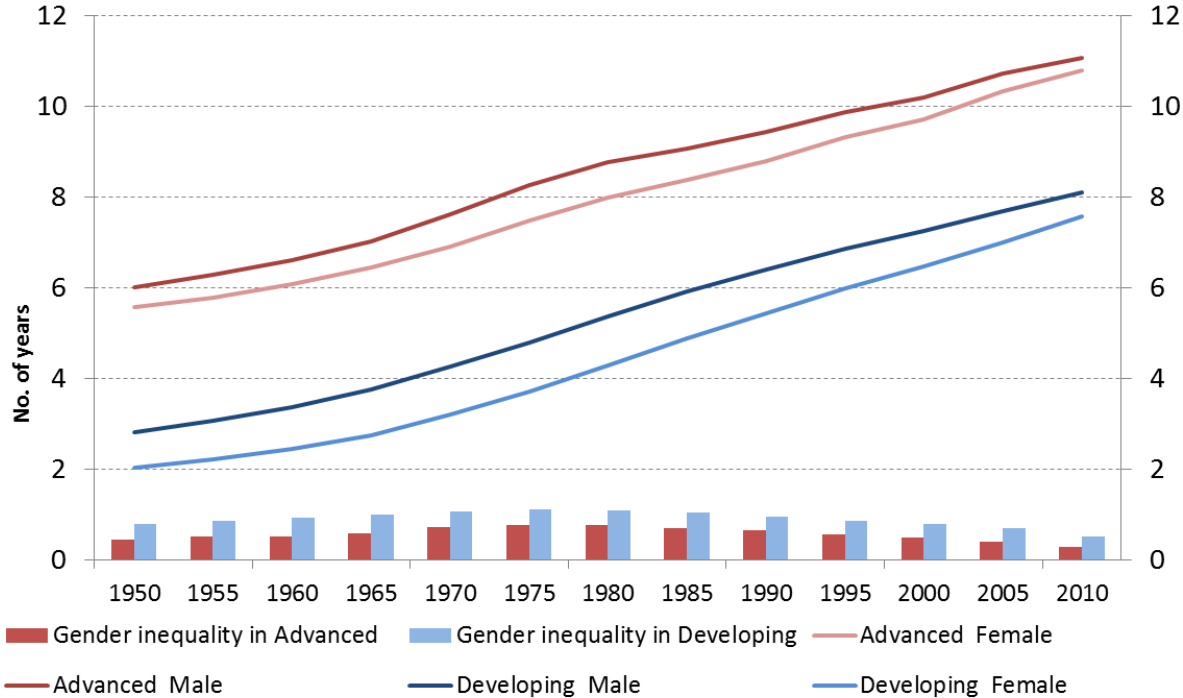
Fig 2 summarizes educational attainment in those two broad regions among males and females since 1950. This shows that significant improvements have been made in developing economies to reduce gender inequality. Female average years of schooling has increased from 2 years in 2050 to 7.6 years for population over age 15 in developing countries, at an annual growth rate of 2.22%, much faster than male schooling which grew at 1.78% since 1950.

¹ Average years of schooling for developing and advanced are calculated using arithmetic mean.

However, this advancement in female education has also been seen in advanced economies. The gap between male and female educational attainment has shrunk as female educational attainment is catching up more quickly than male.

But, the gap in average years of schooling between developing and developed economies has narrowed very insignificantly, less than 1 year in the past 40 years where the gap remains above 3.5 years in 2010.

Fig: 2 Average years of schooling and gender inequality among female and male in advanced and developing economies



Source: Adapted from Barro and Lee (2013) data set

Barro and Lee (2013) argues a possible factor for this slow reduction in this gap is that in advanced countries a higher proportion of population is getting higher level of educations.

For other variables in the model, we have collected purchasing power parity (PPP) and national income account converted real GDP per capita which is derived from growth rates of c, g, I, at 2005 constant prices (rgdpl). We have collected investment to GDP ratio (ki), government consumption ratio (kg), openness ratio (openk), population (pop) from The Penn World Table

7.1 (2012) for 189 countries for the years 1950 to 2010. In our research, we have included 140 countries which are common in Barro and Lee (2013) and PWT 7.1 data set for the period of 1950 to 2010.

3.3 Econometric Analysis and Estimation Technique

Many alternative estimation techniques are available for panel model in growth convergence regressions. In this research, we first use the empirical framework suggested by Islam (1995) and Barro (2001) adopted for panel data and then use GMM estimators that correct for serial correlation and endogeneity among the explanatory variable and then compare the results.

Following Coulombe, Tremblay, & Marchand (2004) and Islam (1995), we use five years of time interval. In a panel data model,

$$\ln y_{it} - \ln y_{it-1} = \lambda \ln y_{it-1} + \beta_1 \ln(h_{it-1}^*) + \beta_2 \ln(s_{it}) - \beta_3 \ln(g_{it}) + \beta_4 \ln(open_{it}) + \mu_i + \nu_t + \varepsilon_{it}$$

$i = 1 \dots 140$ for 140 countries, $t = 1955 \dots 2010$. We include time fixed effect (ν_t) using T-1 dummies to control for common trends and common shocks and country fixed effect (μ_i) to control for time-invariant heterogeneity across countries.

The dependent variable is the growth rate of real GDP per capita for each of the 13 periods. For example for the first period where $t=1955$, growth rate is calculated for the period of 1950-1955. Following Barro (2001) and Islam (1995) human capital variable (h^*) is measured by average years of schooling at the beginning of each period in the regression. Investment to GDP ratio (s), government consumption ratio (g) and openness ($open$) are previous 5 years average, for example for $t=1955$, the average of 1950-1955 is used as explanatory variable.

As mentioned earlier, in fixed effect panel approach, time invariant control variable, rule-of-law indicator, democracy indicator, geography etc. cannot be included in the regression. The description of the variables of the model can be found in table 1.

Table 1**Definitions of the variables**

Dependent Variables	Definitions	Period
Growth rate of real GDP per capita	Growth rate of PPP converted GDP per capita (Laspeyres) for five year period, derived from growth rates of c, g, i, at 2005 constant prices	1955-2010
Independent variables		
log of real GDP per capita	log of initial level of PPP converted GDP per capita (Laspeyres) at the beginning of the period, derived from growth rates of c, g, i, at 2005 constant prices	1950-2010
Average years of education attained	Average years of school attainment of total population over age 15 years	1950-2010
Average years of primary education attained	Average years of primary school attainment of total population over age 15 years	1950-2010
Average years of secondary education attained	Average years of secondary school attainment of total population over age 15 years	1950-2010
Average years of tertiary education attained	Average years of tertiary school attainment of total population over age 15 years	1950-2010
Male average years of schooling	Male average years of schoolings for total population over age 15 year	1950-2010
Female average years of schooling	Female average years of schoolings for total population over age 15 years	1950-2010
Investment to GDP ratio	Previous 5 year period average of investment share of PPP converted GDP per capita at 2005 constant prices	1955-2010
Consumption to GDP ratio	Previous 5 year period average of consumption share of PPP converted GDP per capita at 2005 constant prices	1955-2010
Openness to GDP ratio	Previous 5 year period average of openness at constant 2005 prices (%). The openness ratio is the ratio of export plus imports to GDP	1955-2010
Advanced economies	Dummy variable if the country is among one of the advanced economies listed in the appendix, then 1, otherwise 0	1950-2010

Table 2**Summary of the variables**

Dependent Variables	Mean	Std. Dev.	Obs.	Min	Max	Skewness	Kurtosis
Growth rate	0.02	0.03	1349	-.23	0.24	-0.27	8.55
Independent variables							
log of real GDP per capita	8.38	1.29	1489	5.08	11.82	-0.01	2.10
Avg. years of schooling	5.45	3.18	1898	.02	13.18	0.20	2.02
Avg. years of primary schooling	3.59	1.90	1898	.02	8.88	0.10	2.25
Avg. years of sec. schooling	1.66	1.40	1898	0	6.87	0.93	3.13
Avg. years of tertiary schooling	0.20	0.24	1898	0	1.68	2.10	8.65
Male avg. years of schooling	5.88	3.08	1898	0.03	13.36	0.13	2.09
Female avg. years of schooling	5.04	3.33	1898	0.01	13.23	0.24	1.96
Investment to GDP ratio	22.37	10.12	1439	1.58	64.59	.67	3.91
Consumption to GDP ratio	9.99	5.86	1439	0.32	41.15	1.81	7.62
Openness to GDP ratio	66.57	47.90	1439	3.75	418.35	1.94	9.93

Table 2 shows statistical description of the variables used in the model. Over the period of 1950-2010 with 5 year interval, annual average growth rate of 140 countries is 2.1%, which ranges from -23% to 24% with standard deviation of 0.034.

As discussed before, average years of schooling in 140 countries was 5.45 years over the past 60 years, had an increasing trend over this period, varies from 0.02 years to 13.18 years among the countries over time with standard deviation of 3.18 years.

Male average years of schooling over the period is 5.88 for 140 countries included in the model, which is slightly higher than female average years of schooling (5.04 years) with lower standard deviation than female as expected.

Investment to GDP ratio has mean of 22.37% with standard deviation of 10.12% whereas mean of consumption to GDP ratio is 9.99% over the period.

4.0 Results

4.1 Standard Fixed Effect Model

Based on the econometric estimation technique discussed above, we present our fixed effect panel model estimation result for all countries for the period of 1955 to 2010 in table 3. In the first column of table 3, we present the regression result where human capital is measured as average years of schooling, keeping the other control variables unchanged. In the second column, we disaggregate the average years of schooling at three levels- primary, secondary and tertiary and test the impact of educational attainment on transitional growth rate. In the third column we test the impact of educational attainment of males and females on growth simultaneously. The fourth and fifth columns of the table show the result where we control for male and female educational attainment separately in the growth regression.

Before focusing on educational attainment variables, we summarize the results for the other control variables as follows.

Initial level of log of real GDP per capita: We find negative and significant impact of initial level of real GDP per capita on growth rate. This result confirms the empirical evidence for growth convergence theory; speed of convergence is estimated to be 4.5% per year using the following equation;

$$\text{Speed of convergence, } \lambda = -\frac{\ln(1+\tau\beta)}{\tau}$$

Here, τ is 5 with 5 year time period, β is estimated coefficient for initial log of GDP per capita.

Investment to GDP ratio: We find significant positive relationship between investment to GDP ratio and transitional growth rate in all equations which is similar to previous findings of existing growth papers. The estimated co-efficient is 0.001 (s.e.0.0054) which means that a 10% increase in average investment to GDP ratio raises the transitional growth rate by 0.01% per year.

Government consumption to GDP ratio: Government consumption to GDP measures public outlays, which may reduce public productivity (Barro, 2001). As expected, the estimated effect of government consumption to GDP ratio on growth rate is significantly negative in all regressions which implies that a 10% increase in government consumption ratio is estimated to reduce the growth rate by 0.015% per year.

Openness ratio: The estimated effect of openness ratio on growth is significantly positive, which is in line with Barro (2001) and Coulombe, Tremblay, & Marchand (2004) studies. The estimated coefficient is 0.0001 (s.e. 0.00004) which means a 10% increase in the openness ratio may increase the growth rate by 0.001% per year

Human Capital and Growth rate:

We find that initial stock of average educational attainment has a positive impact on growth rate, but lacks significant explanatory power, presented in Column I. The estimated co-efficient is 0.002 (s.e. 0.001). The result is in line with Islam (1995) and other studies mentioned in Cohen and Soto (2007).

In Column (II), we present the regression results of the educational attainment at three levels- primary, secondary and tertiary. We find positive impact of primary and secondary education on growth rate, but it also lacks significance. The estimated co-efficients are 0.002 (s.e. 0.002) and

0.001 (s.e. 0.002) for primary and secondary school attainment respectively. However, the estimated co-efficient of tertiary education is negative, but insignificant. In Column (III) we find a significant positive impact of female average educational attainment. The estimated coefficient is 0.006 (s.e.0.002) whereas the co-efficient of male average educational attainment is -0.004 (s.e 0.002) and has marginal significance explanatory power. In this regression, we estimate female average educational attainment along with male average educational attainment, keeping other variables unchanged. Male and female educational attainment is measured as average years of schooling at all levels in a country for a period.

However, in the regression with male educational attainment (not including female educational attainment) it is estimated to have positive impact on growth rate (Column IV) but not significant. In Column (V) shows the result of female educational attainment (not including male educational attainment). We find no significant impact of female education on the growth rate, but the relationship remains positive. This result contrasts with Barro (2001) where male secondary and higher education is estimated to have positive and significant relationship and female secondary education is estimated negative, but insignificant.

This positive, but insignificant relationship with human capital in a fixed effect model of our study is in line with the result of Islam (1995) and other studies mentioned in Cohen and Soto (2007).

Table: 3 Fixed-effect model estimation**Results of fixed effect model**

Independent variables	Column (i)	Column (ii)	Column (iii)	Column (iv)	Column (v)
log of real GDP per capita	-0.40*** (-13.08)	-0.04*** (-12.48)	-0.04*** (-13.34)	-0.04*** (-13.06)	-0.04*** (-13.16)
Avg. years of schooling	.002 (1.10)				
Avg. years of primary schooling		0.002 (1.02)			
Avg. years of sec. schooling		0.001 (0.6)			
Avg. years of tertiary schooling		-0.002 (-0.25)			
Male avg. years of schooling			-0.005* (2.06)	0.0002 (0.17)	
Female avg. years of schooling			0.006** (2.76)		.002 (1.84)
Investment to GDP ratio	0.001*** (7.30)	0.001*** (7.21)	0.001*** (7.33)	0.001*** (7.18)	0.001*** (7.40)
Consumption to GDP ratio	-0.001*** (-5.04)	-0.002*** (-5.07)	-0.001*** (-4.87)	-0.001*** (-5.05)	-0.001*** (-5.00)
Openness to GDP ratio	0.0001** (3.13)	0.0001** (317)	0.0001** (2.73)	0.0001*** (3.12)	0.0001**** (3.05)
Year 1960	0.003 (0.47)	0.003 (0.48)	0.003 (0.58)	0.003 (0.48)	0.003 (0.48)
Year 1965	0.02*** (3.40)	0.02*** (3.42)	0.02*** (3.57)	0.02*** (3.49)	0.02*** (3.37)
Year 1970	0.02*** (4.31)	0.02*** (4.33)	0.02*** (4.59)	0.02*** (4.45)	0.02*** (4.29)
Year 1975	0.02*** (3.63)	0.02*** (3.65)	0.02*** (4.05)	0.02*** (3.84)	0.02*** (3.62)
Year 1980	0.02*** (3.72)	0.02*** (3.76)	0.03*** (4.20)	0.02*** (3.99)	0.02*** (3.72)
Year 1985	0.008 (1.24)	0.008 (1.26)	0.01 (1.78)	0.01 (1.63)	0.007 (1.11)
Year 1990	0.02 (2.95)**	0.02** (2.96)	0.02*** (3.44)	0.02*** (3.37)	0.02** (2.87)
Year 1995	0.01 (1.93)	0.01* (1.95)	0.02** (2.41)	0.02*** (2.42)	0.01 (1.75)
Year 2000	0.03*** (3.46)	0.03** (3.47)	0.03*** (3.88)	0.03*** (3.98)	0.02*** (3.34)
Year 2010	0.01*** (3.67)	0.03** (3.68)	0.04*** (4.49)	0.04*** (4.25)	0.03*** (3.51)
# of observations	1349	1349	1349	1349	1349

*t-statistics is reported in the bracket

4.2 Dynamic Panel Model

Serial correlation among the explanatory variables in a fixed effect model may cause bias in the estimated co-efficient of the explanatory variables as mentioned and discussed in Islam (1995) and in Coulombe, Tremblay, & Marchand (2004). Islam (1995) and Coulombe, Tremblay, & Marchand (2004) argue that in panel estimation explanatory variables might be serially correlated for which the average effects evaluated might become inconsistent. The fixed effect and random effect estimators of the panel data model with lagged dependent variable is biased in least square methods. Lagged dependent variable is correlated with the error term, as the dependent variable is also a function of unobserved country fixed effect, μ_i (Ledyeva & Linden, 2008). Coulombe, Tremblay, & Marchand (2004) also mention that consequences for not correcting for serial correlation are that the estimated speed of convergence might be biased upwards.

We test for serial correlation using Langrange Multiplier (LM) test, and find first order auto correlation in the regression (p value= 0.000).

To correct this serial correlation problem in the regression and to overcome the endogeneity, we follow Ledyeva & Linden (2008) and use a dynamic panel data model and include a generalized method of moments (GMM) estimator which will correct for this bias using first difference of the explanatory variables as instruments for explanatory variables.

Arellano and Bond (1991) derives a consistent generalized method of moments (GMM) estimator for the parameters of the model. This estimator is ideal for many panels and few periods, but requires no auto-correlation in the errors. According to Ledyeva & Linden (2008), GMM estimator calls for first differencing and using lags of the dependent and explanatory variables as instruments for the lagged dependent variables. This is a simultaneous estimation of a system of equations where one equation can be used for each year using different

instruments for the lagged dependent and right hand side explanatory variables. Arellano-Bond estimators have one or two step variants. Arellano and Bond (1991) find that robust two step VCEs are biased, so many applied empirical works have focused on the results showing one-step estimator than two-step estimator. Windmeijer (2005) derives a bias-corrected (WC) robust estimator for VCEs of two-step estimators, which is potentially very useful in this class of models as mentioned in Ledyaeva & Linden (2008). In our study we report two-step variants of the estimators which are obtained using bias-corrected (WC) two-step covariance matrix derived by Windmeijer (2005).

We report the results of Arellano-Bond dynamic panel data estimation in table 4. We use the initial level of log of GDP per capita and initial level of years of schooling as explanatory variables keeping other variables unchanged as fixed effect model. We specify 1 lag of the dependent variables to be included in the model. The estimation includes no constant and lags from 2 of n from on back to create the GMM-type instruments and first difference of all the exogenous variables are used as standard instruments. GMM-type instruments use the lags of a variable to contribute multiple columns to the instrument matrix, whereas each standard instrument contributes one column to the instrument matrix. Two statistics evaluate the validity of the instruments used. The Sargan statistics of over-identifying restrictions tests the hypothesis that the instruments are not correlated with the residuals, which is an essential hypothesis for the consistency of the estimators (Ledyaeva & Linden, 2008). According to Stata 12 Base Reference Manual (StataCorp., 2011), Arellano-Bond methodology assumes that *“when the idiosyncratic errors are independently and identically distributed (i.i.d), the first-differenced errors are first order serially correlated... autocorrelation in the first-differenced errors at an order higher than 1 implies that the moment conditions used by GMM are not valid”*(5). In table 4 we include the Sargan, AR (1) and AR (2) test results.

Table 4 Arellano-Bond dynamic panel data estimation

Results of GMM Two Step model

Independent variables	Column (i)	Column (ii)	Column (iii)	Column (iv)	Column (v)
Lag (1) of Growth rate	-0.17*** (-11.45)	-0.17*** (-11.49)	-0.16*** (-11.19)	-0.17*** (-10.65)	-0.17*** (-11.89)
log of initial real GDP per capita	-0.12*** (-29.74)	-0.12*** (-28.48)	-0.12*** (-29.35)	-0.11*** (-26.79)	-0.12*** (-30.05)
Initial avg. years of schooling	0.02*** (16.32)				
Initial avg. years of primary schooling		0.01*** (4.05)			
Initial avg. years of sec. schooling		0.02*** (7.97)			
Initial avg. years of tertiary schooling		0.01 (0.71)			
Initial male avg. years of schooling			0.005 (1.80)	0.01*** (13.82)	
Initial female avg. years of schooling			0.01*** (4.68)		0.02*** (16.82)
Investment to GDP ratio	0.001*** (13.40)	0.001*** (13.09)	0.001*** (13.54)	0.001*** (13.06)	0.001*** (13.64)
Consumption to GDP ratio	-0.001*** (-5.89)	-0.002*** (-5.64)	-0.002*** (-5.64)	-0.002*** (-6.70)	-0.002*** (-5.41)
Openness to GDP ratio	0.0002** (6.34)	0.0002*** (5.42)	0.0002** (6.11)	0.0003*** (7.13)	0.0002*** (5.76)
Sargan test for instrument validity	76.75	75.94	76.64	78.08	76.52
Test for residual AR (1)	P value=0.02 -1.3293	P value=0.02 -1.2106	P value=0.02 -1.3722	P value=.02 -1.3776	P value= 0.02 -1.3723
Test for residual AR (2)	P value= 0.18 -1.1249	P value=0.23 -1.0992	P value=0.17 -1.1197	P value=0.17 -1.1895	P value= 0.17 -1.1631
No of instruments	P value=0.23	P value=0.28	P value=0.27	P value=0.24	P value= 0.25
# of observations	1069	1069	1069	1069	1069

*t-statistics is reported in the bracket

In contrast to our previous result, we find a significant positive relationship between average years of schoolings and growth rate presented in Column (I). It is estimated that a one year increase in average years of schooling in the initial level of the period for the total population over age 15 may increase the growth rate by 1.56% (s.e= 0.004). This result is very close to

Barro and Lee (1994) where the estimated coefficient of male secondary school attainment is 0.01 (s.e. 0.0041).

Column (II) presents the relationship between average years of schooling disaggregated by educational level for total population age over 15. We find significant and positive impact of primary and secondary education on the growth rate. The estimated co-efficients are 0.01 (s.e 0.002) and 0.02 (s.e. 0.003) respectively, suggesting that an additional year of primary schooling and secondary schooling for total population over age 15 raises the transitional growth rate by 0.86% and 2.37%. However, post-secondary schooling (tertiary) education has a positive impact on growth rate, but not significant.

In column (III) we present the impact of male and female educational attainment on the growth rate, keeping other explanatory variables unchanged. We find female educational attainment at the initial level of the period has significant positive impact on growth, while male educational attainment has a positive, and borderline significant effect (p value= 0.07) on the growth rate of a country. In the standard pooled fixed effect model, we get positive and significant relationship with female educational attainment and growth rate, but male educational attainment has the wrong sign and remains significant. In the dynamic panel model, when we correct for serial correlation and endogeneity, we get positive and significant impact of female educational attainment on growth rate and positive and borderline significant impact of male educational attainment on growth rate at 10% level of significance.

In Column (IV) and Column (V), we estimate male educational attainment and female educational attainment separately and get positive and significant impact on growth rate, as expected. Sargan test statistics for each equation presents strong evidence to support the null hypothesis that the overidentifying restrictions are valid at 1% level of significance (p value=

0.02) and autocorrelation tests confirm no autocorrelation in the first differenced errors at order higher than 1 which is a requirement for valid GMM estimation.

Other than human capital variable, the results remains consistent for investment to GDP ratio, openness ratio, government consumption ratio with fixed effect model presented in table 3. We also confirm conditional convergence with estimated co-efficient at -0.12 which translate convergence speed of 1.75% per year. This is lower than the fixed effect model result of 4.5%. Islam (1995) finds annual speed of conditional convergence is 0.0913 and M-R-W obtains 0.0203 for OECD countries.

5.0 Conclusion

A modification of Islam (1995) and Barro (2001) empirical framework of growth model is specified to study the impact of stock of human capital measured as average years of educational attainment using the recent Barro and Lee (2013) data set across 140 countries for the period 1950-2010. We have utilized both fixed effect and dynamic panel model. Results imply that average years of schooling has positive and significant relationship with transitional growth rate and has long term positive impact on GDP per capita. This result is consistent with Barro (2001) where the study finds significant positive relationship with male secondary educational attainment and growth rate. However, the result contrasts with the female educational attainment as Barro (2001) finds negative or insignificant impact of female secondary educational attainment on growth rate. The result of this study is consistent with Coulombe, Tremblay, & Marchand (2004) as the impact of female education is more significant than male educational attainment.

We find interesting results regarding the composition of the educational attainment. It is estimated that primary and secondary education have more significant impact than post-

secondary educational attainment on growth rate. This study also confirms conditional convergence among the countries.

To extend the study in the future, quality of education can be included in the model where evidence suggests that quality of education may have a more significant impact on growth rate. However, data limitation may not allow to control for the quality of education for a large sample of countries for a longer time period. Variables to control for quality of education, for example international test scores can be explored to include in the growth model.

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Appendix

Table A1: Countries Included in the study

Advanced Countries

Australia	Ireland
Austria	Iceland
Belgium	Italy
Canada	Japan
Switzerland	Luxembourg
Germany	Netherlands
Denmark	Norway
Spain	New Zealand
Finland	Portugal
France	Sweden
United Kingdom	Turkey
Greece	USA

Devolping Countries

Afghanistan	Haiti
Albania	Honduras
Algeria	Hungary
Argentina	India
Armenia	Indonesia
Bahrain	Iran (Islamic Republic of)
Bangladesh	Iraq
Barbados	Israel
Belize	Jamaica
Benin	Jordan
Bolivia	Kazakhstan
Botswana	Kenya
Brazil	Kuwait
Brunei Darussalam	Kyrgyzstan
Bulgaria	Lao People's Democratic Republic
Burundi	Latvia
Cambodia	Lesotho
Cameroon	Liberia
Central African Republic	Libyan Arab Jamahiriya
Chile	Lithuania
China	Malawi
China, Hong Kong Special Administrative Region	Malaysia
China, Macao Special Administrative Region	Maldives

Colombia
Congo
Costa Rica
Cote d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic
Democratic Republic of the Congo
Dominican Rep.
Ecuador
Egypt
El Salvador
Estonia
Fiji
Gabon
Gambia
Ghana
Guatemala
Guyana
Rwanda
Saudi Arabia
Senegal
Serbia
Sierra Leone
Singapore
Slovakia
Slovenia
South Africa
Sri Lanka
Sudan
Swaziland
Syrian Arab Republic
Taiwan
Tajikistan
Uruguay
Venezuela
Viet Nam

Mali
Malta
Mauritania
Mauritius
Mexico
Mongolia
Morocco
Mozambique
Myanmar
Namibia
Nepal
Nicaragua
Niger
Pakistan
Panama
Papua New Guinea
Paraguay
Peru
Philippines
Poland
Qatar
Republic of Korea
Republic of Moldova
Reunion
Romania
Russian Federation
Thailand
Togo
Tonga
Trinidad and Tobago
Tunisia
Uganda
Ukraine
United Arab Emirates
United Republic of Tanzania
Yemen
Zambia
Zimbabwe