Better Health Impacts on Education

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Abstract

We analyze the effects of life expectancy on human capital with a big longitudinal yearly dataset over 2019-2015 for 143 countries. Our panel estimators capture country fixed effects and persistence in human capital. The preferred baseline estimates show that there is a significantly positive and robust relationship between life expectancy and human capital. When addressing endogeneity of life expectancy with instruments, our preferred results remain comparable. Our analysis suggests that parents with improved life expectancy prefer quality child over quantity by reducing fertility and investing savings in child education.

Keywords: Human Capital, Life Expectancy, Mortality, Survival, Saving, Fertility

JEL-Classification: I210, I250, I120, I140, E210, J130

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1 Introduction

Human capital is a multidimensional concept in economics: It forms from schooling, higher education, training and experiences from jobs, valuable information and state of health (Schultz, 1993). Human capital as innate or acquired abilities accrues additional welfare to individuals embodied it as well as creates a new knowledge environment which can have a large effect on economic progress. Since human capital attached with individuals cannot be isolated from them, its effects on society last for long time. High human capital obtained in previous generation can have large impacts on human capital of present generation: Human capital acts in a dynamic system (Ehrlich and Lui, 1991; Ben-Porath, 1967). On the other hand, health condition plays a pivotal role in achieving human capital as elements of human capital count on it. To maintain a good health requires preventive and treatment interventions from health care system. Health in developed countries is a automatic byproduct of economic progress whereas it is not for poor nations because economic growth is not enough there and hence they cannot have sufficient resources to design a standard health care system that covers all people (Sachs, 2002). In consequence, communicable diseases prevent present generation from obtaining acquired abilities in poor nations. More importantly, current generation with diseases environment produces less human capital in poor countries and so future generation will eventually contribute less to economic growth and development. Thus two health regimes are: More healthier nations with less mortality and less healthier countries with more morality rates, the combined effect of these regimes determines the human capital globally.

The existing theoretical and empirical literature acknowledges that life expectancy at birth has a relationship with saving and fertility: These are channels via which life expectancy works on human capital. For instance, Ando and Modigliani (1963) related the variation of savings to the entire life with life cycle hypothesis: Saving is derived from a long-run relationship between consumption and income. On the other hand, Ben-Porath (1967) underscores the channel such as saving through which longevity acts on human capital while constructing a theoretical analysis of life cycle and dynamic path of human capital formation. Ehrlich and Lui (1991) explore that, in a dynamic system of human capital, longevity contributes in human capital through mechanisms such as savings and fertility. They argue that parents can have a great incentive to save for children as this saving is invested in human capital for children in order to receive benefits from children in old age. In addition, they suggest that young-age longevity has negative effects on fertility while old-age has no effect. A longer life expectancy can save more which in turn goes to invest in human capital (Zhang and Zhang, 2005). Barro (1996) argues that an increase in life expectancy reduces fertility through demographic transition with varying lags. On the other hand, Aghion et al. (2010) find that an improvement in life expectancy motivates individuals to save and invest more in human capital and reduces fertility. These papers suggest that life expectancy increases saving that is further invested in education; thus higher human capital to children is obtained and served as coverage of insurance for old age of parents. On the other hand, longer life - through a demographic transition - leads to a low birth rate from a high birth rate in the family provided individuals live in a environment of a lower mortality rate. These mechanisms imply parents with better health prefer quality child over quantity.

The link between health and human capital has been documented more theoretically than empirically in literature. Most papers relate health measured by child, maternal and adult mortality rates to schooling: An improvement in health leads to an increase in school enrollments and hence human capital (Bleakley, 2007; Jayachandran and Lleras-Muney, 2009; Lorentzen et al., 2008; Meltzer, 1992; Preston, 1975).

There are few authors who directly establish an empirical link between life expectancy at birth and education attainment from the primary interest using a longitudinal dataset for a large number of cross-section units and long time periods in this literature. For example, for finding the relationship between life expectancy and GDP per capita, Acemoglu and Johnson (2007) also investigate the impact of life expectancy on average years of schooling - one of the outcome variables - to show that there is a correlation between life expectancy and education and thus productivity over 1940-1980 for 53 countries. Their finding does not support a significant relationship between both variables. However, this is not main interest of the paper. Using static fixed effects (SFE) estimator, life expectancy at birth has a positive and significant relationship with the average years of schooling (school cohort aged 5-10 in year t) covering period 1940-1980 for 70 countries (Hansen, 2013). Thus there is a mixed evidence in literature regarding the link between income and life expectancy at birth.

Both papers use human capital as average years of schooling while we use human capital index estimated from average schooling years of Barro and Lee (2013), and Cohen and Leker (2014) in the total population over the age of 25 and an assumed rate of return to education from Psacharopoulos (1994) using Mincer equation. Also, we use a big yearly longitudinal dataset for human capital and life expectancy at birth: Both panel dimensions, cross-section units (N) extends to 139 and time dimension (T) goes to 56 covering the whole world. Time regimes used in their analyzes ended in 1980 or 2000 while data used in our paper range from 1960 to 2015, in particular, the time regime we used from 2000 to 2015 captures the effects of Millennium Development Goals (MDGs): Life expectancy rises largely by reducing child deaths globally. Importantly, unlike others, our panel units are very large implying that our data have more variability and hence can produce more reliable parameter estimates. Since each panel unit has a long time series data and under the stationary process of panel units, we can estimate parameters of interest consistently

Additionally, unlike SFE estimation, past histories of dependent variable are important determinants of present dependent variable. For instance, present generation is inherited valuable knowledge or human capital from the past generation which is considered as an important determinant of current capital. More importantly, our paper follows Ehrlich and Lui (1991) and Ben-Porath (1967): Both papers analyze that human capital develops following a dynamic system. For example, Ehrlich and Lui (1991) study that past human capital has a potential impacts on current human capital which converges to a long-run equilibrium. A high persistent human capital implies future generation can enjoy more benefits from human capital relative to predecessors via a dynamic system. However, a longer period of famine, war, and diseases can bring down human capital from a high equilibrium to a stagnant equilibrium. On the other hand, Ben-Porath (1967) argues that with the speed of adjustment in dynamic process of human capital, the stock of capital finally is settled to an individual. Based on these, we are motivated to apply dynamic panel estimators to discover the impacts of life expectancy on human capital. Thus our main interest, outcome variable, conceptual framework, and panel data dimensions differ largely from the existing literature: Our analysis gives difference in empirical evidence.

In this paper, our interest lies in establishing a direct relationship between life expectancy at birth and human capital[1]. To do this, we use conditional correlation of life expectancy on education for a large number of countries and years. We employ a dynamic panel model which controls for country fixed effects and dynamics of human capital. The lagged dependent variables added to model capture the persistence in human capital. This allows us to find the consistent estimate of parameter of interest and the long-run effects of life expectancy on education. Our dynamic model gives us quite different estimates of parameter of interest compared to a static panel model[2]. Furthermore, since health is an endogenous variable, without addressing this, our estimates may be biased and inconsistent. Instrumenting health with its lags, we use GMM estimator. In addition, our paper analyzes the channels via which life expectancy acts on human capital.

The contributions of this paper are several: First, we find a significantly positive and robust effect of health on education attainment. Second, we use a yearly largest updated panel data with respect to both dimensions ($N = 139$, $T = 56$) that covers the whole world. Third, this paper discovers channels through which health affects the education. Our baseline dynamic within estimates demonstrate that there is a significantly positive relationship between life expectancy and human capital. The empirical evidence suggests that a 1% improvement in life expectancy at birth leads to around 0.021 rise in human capital: On average, if life expectancy at birth rises 20 years (for example, from 1950 to 1970), human capital rises by 1.394 which is large in magnitude. We uncover comparable results when using internal instruments for addressing endogeneity of health. Our results suggest that health affects education by decreasing fertility and increasing saving.

[1]In this paper we use education and human capital interchangeably.
[2]Life expectancy at birth and health are used in this paper interchangeably.

The paper is organized as follows: Section 2 presents the data sources and description. Section 3 discusses our dynamic panel data models and results. Section 4 conveys channels via which health affects education and concluding remarks are given in section 5.

2 Data Sources and Description

Our goal in this paper is to find a relationship between education and life expectancy at birth: Dependent variable is human capita index (education) and independent variable is life expectancy. The data on human capital index is used from the Pen World Table (PWT, 2019) which is constructed from average schooling years of Barro and Lee (2013), and Cohen and Leker (2014) in the total population over the age of 25 and an assumed rates of return to education from Psacharopoulos (1994) using Mincer equation. From the World Bank's World Development Indicators (World Bank, 2019), we use data on life expectancy at birth, preprimary, primary, secondary and tertiary school enrollments (percentage of students enrolled), primary and adolescents school drop outs (percentage of out of school); the alternative health indicators such as under-five child, maternal mortality rates (per 1,000 live births), male adult mortality (per 1,000 male adult) and female adult mortality (per 1,000 female adult), female and male survivals to age 65 (percentage of cohort); other variables such as GDP per capita (constant U.S. dollar), public spending on health (percentage of government expenditure), saving (percentage of GDP) and total fertility rate (the number of children born per woman). Mean years of schooling (years) and expected years of education (years) are used from the Human Development Data (UNDP, 2019). Table 1 provides the summary statistics of outcome and explanatory variables.

Table 1: Descriptive Statistics

	Obs	Mean	S.D.
Human capital index	7,069	2.054	0.720
Total life expectancy at birth (years)	10,088	63	11
preprimary school enrollment (percent)	5,017	47	34
Primary school enrollment (percent)	6,792	96	23
Secondary school enrollment (percent)	5,771	63	34
Tertiary school enrollment (percent)	5,131	22	22
Mean years of schooling (years)	4,328	7	3
Expected years of education (years)	4,667	12	3
Primary school drops out (percent)	3,870	14	18
Adolescents school drops out (percent)	2,062	17	20
Neonatal mortality (per 1,000)	7,804	25	19
Infant mortality (per 1,000)	8,960	54	47
Child mortality under five (per 1,000)	8,960	81	79
Maternal mortality (per 1,000)	4,654	274	365
Female adult mortality (per 1,000)	10,013	204	119
Male adult mortality (per 1,000)	10,013	274	115
Female survival (rate to age 65)	10,024	68	18
Male survival (rate to age 65)	10,024	58	16
GDP per capita	8,097	$9,744	$14,986
Public spending on health (percent)	3,712	11	4
Saving (percent)	5,170	20	13
Fertility (born per woman)	10,092	4	2

Note: The sources and the detailed description of variables are provided in the text.

3 Panel Data Estimators and Results

3.1 Dynamic Fixed Effects Estimator (baseline)

Modeling a relationship between education and life expectancy, we employ a dynamic panel model. Our model is:

$$e_{it} = \beta h_{it} + \sum_{l=1}^{q} \delta_l e_{i(t-l)} + \alpha_i + \gamma_t + u_{it} \tag{1}$$

where $i = 1, 2, \ldots, 139$, are cross-sectional units (countries) over T time periods (years) $t = 1960, 1961, 1962, \ldots, 2015$ and lags $l = 1, 2, \ldots, q$; $e, h, e_{t-l}, \alpha, \gamma$ *and* u stand for human capital, log of life expectancy at birth, lags of human capital, country and year fixed effects and the error term respectively. Equation 1 is a static fixed effects estimator (within) when we ignore the second term of this equation. Our goal is to estimate parameter β

which presents a positive effect of improved life expectancy on education: An increase in education attainment is positively correlated with an improvement in life expectancy. Our model considers q lags ($1 \leq l \leq q$) on education to capture the persistence in education. δ_l indicates the persistence in education of l^{th} lag while $\sum_{l=1}^{q} \delta_l$ shows the sum of autoregressive coefficients: It governs the dynamics of education. The error term measures the effects of all sorts of left-out factors that we cannot account for in this model. We can estimate β consistently if our panel estimators satisfy assumption 1:

Assumption 1: $\mathbf{E}(u_{it} \mid h_{it}, e_{i(t-1)}, \ldots, e_{i(t-q)}, \alpha_i, \gamma_t) = 0$, for all h_{it}, $e_{i(t-1)}, \ldots, e_{i(t-q)}$, α_i and γ_t.

This assumption implies conditional mean of error term is zero when health, past education, country and fixed effects are exogenous.

We compute the long-run implied effects of health on human capital after running models. Hence, computation requires the estimated coefficients of β and δ. In consequence, the following formula is used for finding the long-run cumulative effects of health:

$$\frac{\hat{\beta}}{1 - \sum_{l=1}^{q} \hat{\delta}_l}$$

, where $\sum_{l=1}^{q} \hat{\delta}_l$ converges to $m \in (0, 1)$ which implies education is stationary.[3]

Table 2 presents the direct effects of life expectancy on human capital using model 1. Panel A shows estimates for life expectancy employing static and dynamic within estimators while panel B reports results from Arellano-Bond estimator. We have estimated 9 and 8 specifications for panel A and panel B respectively.

In panel A, column 1 reports the estimates of static fixed effects (SFE, within), and

[3]For finding long-run cumulative effects of health, we assume that outcome and explanatory variables are persistent. So, in the long-run equilibrium, $e_{it} = e_{it-l} = e_{ss}$ and thus we derive following formula from equation (1) ignoring α, γ and u for simplicity:

$$e_{ss} = \frac{\beta h_{ss}}{1 - \sum_{l=1}^{q} \delta_l}$$

where e_{ss} indicates a steady-state level of education: $\sum_{l=1}^{q} \delta_l < 1$ conveys stationarity of education and $\sum_{l=1}^{q} \delta_l$ converges to $m \in (0, 1)$.

estimated effect is 0.697. The Figure 3 of Appendix B presents that there is a positive relationship between life expectancy at birth and human capital over the period 1960-2015.

In columns 2 through 9, we report the estimates of dynamic fixed effects estimation using model 1.[4] In column 2 we use one lag to capture the persistence of human capital. The estimated effect of life expectancy at birth is 0.022. On the other hand, the long-run effect of life expectancy is 3.551 which indicates that a 1% increase in life expectancy contributes 0.036 human capital: On average, if life expectancy goes up by around 5 years, human capital rises to about 0.59. The persistence in human capital is 0.994: It is significantly less than one which indicates that human capital is stationary.

Adding one more lag in column 3, we find that long-run cumulative impact of life expectancy is 1.688 which is less than one reported in column 2: An improvement in life expectancy by 1% can lead to 0.017 improvement in human capita. While estimate of first lagged is positive with greater than one and second lagged is negative, the overall persistence level is significantly less one: It remains the same as column 2. This maintains stationarity of human capital in dynamic adjustment process. With controlling for three lags, column 4 demonstrates that implied long-run impacts of life expectancy is 1.771: This estimate is slightly higher compared to the estimate in column 3 while it is less relative to the estimate in column 2. But the magnitude of autoregressive coefficients significantly remains the same as in previous specifications (columns 2 and 3) which show that human capital follows stationary process.

While including four and five lags in our model in columns 5-6, the dynamic estimated effects are almost the same as columns 3 and 4. The long-run estimated effects of life expectancy rise slightly than those of columns 3 and 4. Not surprisingly, the degree of persistence levels are significantly the same as previous specifications implying that dynamic within estimator follows the limit distribution.

When considering six lags in column 7, the dynamic effect of an improvement in life expectancy increases in the long-run equilibrium compared to those of columns 5 and 6. Specification 7 is our preferred estimate: An improvement in health by 1% can lead to

[4]Thoughout this paper, we use dynamic fixed effects or dynamic within or within estimators interchangeably.

0.021 rise in human capital: On average, around a 20-year increase in life expectancy leads to about 1.394 in human capital which is large in magnitude.[5] The sum of autoregressive coefficients governing the dynamics process is less than one which implies human capital is a stationary. The cumulative long-run effects decrease as we control for 7 and 8 lags reported in columns 8 and 9. Human capital remains stationary as the overall persistence for each lag is less than one. The bottom part of Panel A shows the panel unit root test.[6]

The dynamic fixed effects estimator captures the time-invariant unobserved heterogeneity across countries. However, this estimator ignores the time-varying factors which may affect our estimates biased and inconsistent. Never the less, this estimator is consistent if education is stationary and health is exogenous.

Rather than human capital, we also consider alternative outcome variables such as preprimary, primary, secondary and tertiary school enrollments (columns 2-5), mean years and expected years schooling (columns 6-7), school and adolescent drop out (columns 8-9) are reported in Table A.1 of Appendix A. Columns 2-7 of the table reports significantly positive impacts of health while school drop out has a negative relationship (columns 8-9) when using the static fixed effects (within) estimation. Panel A of Table A.2 (Appendix A) shows the dynamic within estimates with the same set of outcome variables of Table A.1: The results are consistent with our preferred estimates (column 7, Panel A, Table 2).

As we add lagged dependent variable in our model, the problem of Nickell bias appears due to its correlation with error term. This bias decreases as time period increases, because it counts on the order of $1/T$ where T is time period. For very large numbers of T, this bias disappears.[7] Our paper uses large number of observations: On average each panel contains 49 observations. This implies bias is less in our paper.

[5] We consider 8 as the maximum lags in our analysis. We set the null hypothesis for choosing preferred lag: $H_0 : \delta_{il} = 0$ on the following augmented Dickey-Fuller regression, $\Delta e_{it} = \theta_i e_{it-1} + \sum_l^q \delta_{il} \Delta e_{it-l} + \epsilon_{it}$ (See Baltigi, 2005 p.254; Wooldridge 2002, ch.18).

[6] In Fisher-type unit root test, H_0: All panels contain unit root; H_1: At least one panel is stationary.

[7] Judson and Owen (1999) demonstrates that for $T = 30$, bias is from 1% to 2% of the true parameter while it is around 2% and 3% when T is 20.

Table 2: The effect of health on human capital

	SFE	Panel A: Dynamic within estimates							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Health	0.697***	0.022***	0.006***	0.006***	0.006***	0.007***	0.007***	0.007***	0.007***
	(0.176)	(0.006)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Education		0.994***	1.875***	1.914***	1.908***	1.902***	1.895***	1.913***	1.919***
first lag		(0.003)	(0.011)	(0.012)	(0.012)	(0.012)	(0.013)	(0.012)	(0.014)
Education			-0.879***	-0.965***	-0.902 ***	-0.895***	-0.890***	-0.911***	-0.930***
second lag			(0.011)	(0.017)	(0.017)	(0.018)	(0.019)	(0.016)	(0.018)
Education				0.048***	-0.075***	-0.017	-0.0155	-0.010	0.004
third lag				(0.009)	(0.015)	(0.013)	(0.012)	(0.009)	(0.010)
Education					0.065***	-0.060***	0.005	0.003	0.0005
fourth lag					(0.009)	(0.022)	(0.015)	(0.014)	(0.013)
Education						0.067***	-0.074***	-0.270***	-0.269***
fifth lag						(0.015)	(0.017)	(0.038)	(0.038)
Education							0.067***	0.497***	0.542***
six lag							(0.015)	(0.073)	(0.072)
Education								-0.225***	-0.325***
seven lag								(0.034)	(0.036)
Education									0.054***
eight lag									(0.011)
Long-run		3.551**	1.688***	1.771***	1.855***	1.942***	2.121***	1.836***	1.999***
effect of health		(1.744)	(0.416)	(0.440)	(0.467)	(0.488)	(0.535)	(0.417)	(0.437)
Persistence in		0.994***	0.996***	0.997***	0.997***	0.997***	0.997***	0.996***	0.996***
education		(0.003)	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Panel unit root									
test (education)									
(P-value)		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	6,947	6,810	6,671	6,533	6,396	6,259	6,122	5,984	5,845
No. of country	139	139	139	139	139	139	139	139	139
		Panel B: GMM estimates							
Health		0.055***	0.010***	0.010***	0.010***	0.011***	0.012***	0.010***	0.011***
		(0.015)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Education		0.978***	1.841***	1.880***	1.870***	1.864***	1.851***	1.884***	1.885***
first lag		(0.004)	(0.017)	(0.017)	(0.017)	(0.018)	(0.019)	(0.017)	(0.019)
Education			-0.846***	-0.933***	-0.864***	-0.859***	-0.847***	-0.882***	-0.893***
second lag			(0.016)	(0.020)	(0.021)	(0.022)	(0.023)	(0.020)	(0.022)
Education				0.049***	-0.077***	-0.018	-0.016	-0.012	0.00002
third lag				(0.009)	(0.015)	(0.013)	(0.012)	(0.009)	(0.011)
Education					0.066***	-0.065***	0.007	0.005	0.003
fourth lag					(0.009)	(0.023)	(0.015)	(0.014)	(0.013)
Education						0.072***	-0.088***	-0.272***	-0.270***
fifth lag						(0.016)	(0.019)	(0.038)	(0.038)
Education							0.088***	0.491***	0.533***
six lag							(0.017)	(0.072)	(0.070)
Education								-0.219***	-0.314***
seven lag								(0.035)	(0.035)
Education									0.052***
eight lag									(0.012)
Long-run		2.521***	2.106***	2.162***	2.240***	2.315***	2.456***	2.285***	2.468***
effect of health		(0.572)	(0.519)	(0.536)	(0.556)	(0.560)	(0.574)	(0.489)	(0.482)
Persistence in		0.978***	0.995***	0.995***	0.995***	0.995***	0.995***	0.995***	0.995***
education		(0.004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
AR2 test									
(P-value)		[0.061]	[0.166]	[0.000]	[0.000]	[0.106]	[0.316]	[0.793]	[0.024]
Observations		6,668	6,530	6,393	6,256	6,119	5,982	5,844	5,706
No. of country		139	139	139	139	139	139	139	139

Note: Dependent variable is human capital while independent variable is log of total life expectancy at birth. Columns 2-9 denote the estimates from 1, 2, 3, 4, 5, 6, 7, and 8 lags of human capital. Robust standard errors against heteroskedasticity and serial correlation at the country level are reported in parentheses. All models include country and year fixed effects. *p <0.10, **p <0.05, ***p <0.01.

3.2 GMM Estimator

The lagged outcome variables are endogenous due to their correlation with error terms. On the other hand, health may be contemporaneously endogenous. Thus there is endogenity problem in our dynamic fixed effects model. To address it, we employ the dynamic IV model or differenced GMM or Arellano-Bond estimator (Arellano and Bond, 1991).[8] The first-difference of equation 1 is given as:

$$\Delta e_{it} = \beta \Delta h_{it} + \sum_{j=1}^{q} \Delta e_{it-j} + \Delta u_{it} \tag{2}$$

where Δ denotes the first-difference and $j = 1, 2, \ldots, q$. Equation 2 shows that time-invariant factor α_i is eliminated from the first-difference while time effects γ_t are ignored as a common effect for all cross-section units. We use lagged outcomes and lagged health in levels as instruments for the first-differenced lagged outcome and first-differenced health. Since the first-differenced lagged outcome is correlated with the first differenced error term, e_{it-1} is no longer be an instruments for the first differenced lagged outcome variable; however, e_{it-2}, e_{it-3},.., are not correlated with the error terms, thus these can be used as instruments for the first differenced outcome variables. On the other hand, h_{it-1} is correlated with the first differenced error terms, but h_{it-2}, h_{it-3},.., are uncorrelated with the error terms and considered as instruments for the first-differenced of health. These instruments in our GMM model must satisfy the following orthogonal moments condition in model 1 to identify β:

$$\mathbb{E}(\Delta u_{it}(h_{is}, e_{is})') = 0, \forall s \leq t-2$$

.

Panel B, Table 2, presents the Arellano-Bond GMM estimates which deals with dynamic panel bias. Columns 2 through 9 indicate that the estimated effects in Panel B

[8] We apply the dynamic IV estimator or differenced GMM or Arellano-Bond estimator interchangeably.

are similar to Panel A. The long-run effects are also similar to our preferred within estimate (Column 7, Panel A). AR2 test on residual is reported at the bottom part of Panel B. The test shows that there is no autocorrelation in columns 3, 6, 7 and 8. Any one out of these four specifications can serve as a consistent estimate. However, we select column 7 in Panel B as the preferred estimates which has the same lag as the within estimator in Panel A. The overall amount of persistence in Panel B is almost the same as Panel A which maintains the stationarity of human capital. We also consider alternative outcome variables rather than human capital: preprimary, primary, secondary and tertiary school enrollments (columns 1-4), mean years and expected years schooling (columns 5-6), school and adolescent drop out (columns 7-8) are reported in Panel B of Table A.2 (Appendix A). The results are consistent with our preferred estimates (column 7, Panel B, Table 2).

In general, we estimate parameter consistently employing dynamic within and Arellano-Bond estimators in Table 2. Since human capital is stationary, the former estimation provides consistent estimates following assumption 1. On the other hand, satisfying orthogonal moments conditions and addressing endogeneity of health, the latter estimation gives consistent estimates. The preferred implied estimate from the former is 2.121 while the latter provides 2.456: Both estimates are similar. Thus we achieve comparable and consistent estimates from these two panel estimators.

Too many instruments are produced while using Arellano-Bond GMM estimator, the instrument count quadratic in T. This is a problem for finite samples which can weaken the Hansen test. Hence, we cannot report the number of instruments and Hansen p-value in Table 2 and onwards. However, this problem can not affect the consistent estimates derived from this estimator. In this aspect, Roodman (2009) suggests to reduce the number of instruments and check the robustness of the results. We reduce our instruments largely in subsection 3.3 and findings remain similar to preferred estimates (see Table A.3, columns 4-7, Appendix A). Moreover, in the same subsection, we modify our models including different strategies in both dynamic fixed effects and GMM estimators and check robustness of our preferred estimates reported in Table 2.

3.3 Robustness

Our dynamic within estimates absorb the time invariant factors by country fixed effects and GMM estimator addresses the endogeneity of health with internal instruments in Table 2. However, exogenous sources of variation in health due to time-varying factors - which may affect the health and human capital simultaneously - is not considered. In this case, our dynamic within, and Arellano and Bond estimates may be biased and inconsistent. To check robustness of our results, we conduct various specifications accounting for several time varying controls.

Column 1 of Table 3 indicates our preferred estimates repeated from column 7 of Table 2 to make comparison. Column 2 of Panel A, Table 3, shows estimates from controlling GDP per capita which is endogenous to life expectancy. Considering lags of it as instruments, we find slightly lower effects of health on education. Column 3 of the table indicates the estimates for considering the public health expenditure which is highly correlated with life expectancy. Our preferred findings remain similar when controlling this factor. Panel B of the table presents Arellano-Bond estimates with the same controls used in Panel A. Column 1 of Panel B is repeated from column 7 of Panel B, Table 2. The estimated and long-run effects of health are comparable with the estimates in column 1. AR2 test in all cases show that there is no autocorrelation implying consistent estimates.

Moreover, this paper uses alternative measures of health such as under-five child, maternal, adult male and adult female deaths are accounted for in our analysis to check robustness of our estimates. Columns 1-6 of Table 4, Panel A and Panel B report mortality impacts on human capital using dynamic within and Arellano-Bond GMM estimates respectively.

Child mortality happens before education begins while maternal and adult deaths occur after the education embodied; therefore, there are larger loss of human capital, specially in the long-run, due to incidence of latter than loss of former which is consistent with our findings (Table 4). For example, specifications in columns 1 and 2 of Panel A (Table 4) show that an improvement in child under-five and maternal deaths contribute

Table 3: The effect of health on education with additional controls

Covariates	Prefe. estim. (1)	Lag GDP per capita (2)	Lag pub. hea.exp (3)
	Panel A: Dynamic within estimates		
Health	0.007***	0.008***	0.016***
	(0.002)	(0.002)	(0.006)
Long run	2.121***	1.966***	3.674***
effect of health	(0.535)	(0.416)	(1.262)
Persistence	0.997***	0.996***	0.995***
in education	(0.0008)	(0.0008)	(0.003)
Observations	6,122	5,560	2,617
No. of country	139	137	139
	Panel B: GMM estimates		
Health	0.012***	0.015***	0.017***
	(0.004)	(0.003)	(0.006)
Long run	2.456***	2.147***	3.361***
effect of health	(0.574)	(0.358)	(1.262)
Persistence	0.995***	0.993***	0.995***
in education	(0.001)	(0.001)	(0.003)
AR2 test (p-value)	[0.316]	[0.376]	[0.872]
Observations	5,982	5,423	2,477
No. of country	139	137	139

Note: Table 3 denotes the robustness check of our baseline results. Columns 2-3 indicate lag of GDP per capita and lag of public health expenditure respectively. All regressors are in log form. The dependent variable is human capital and independent variable is life expectancy at birth and controls. Robust standard errors against heteroskedasticity and serial correlation at the country level are reported in parentheses. All models include country and year fixed effects. We use 3 lags for GDP per capita and 1 for government expenditures health respectively. *p <0.10, **p <0.05, ***p <0.01.

human capital 0.405 and 0.543 in the long-run respectively. Furthermore, protecting adult deaths can add even more human capital in the long-run (Columns 3-4). Also, our model includes other health outcomes such as female and male survival rates to age 65 reported in columns 5-6 of Table 4. The effects are similar to preferred findings while controlling these factors. Panel B demonstrates very similar estimated and long-run effects of deaths to Panel A. The overall persistence in education is less than one implying that education is stationary.

Reducing child mortality can contribute some increase in life expectancy; however, this increase in life expectancy may not contribute in human capital as child mortality happens before schooling. Nonetheless, this reduction may contribute in human capital by increasing saving and reducing fertility. Hence, child mortality effect on education is less in magnitude. On other hand, maternal mortality effects on human capital would affect human capital directly and indirectly. For example, in case of educated mother who is survived from death, while giving birth baby, may enter the labor market and obtain experiences. She would also affect education improving child health. In consequence, this mortality reduction increases more human capital than child mortality reduction. In addition, adult mortality contributes even more in human capital than preceding deaths reduction as while reducing adult deaths male or female, they would enter into labor force or schools and acquire human capital through experiences or knowledge. Not surprisingly, child or maternal or adult deaths decline can increase life expectancy to a extent that each contributes some of human capital. For example, in column 4 of Table 4, Panel A shows that the long-run effect of maternal mortality reduction on education is 0.543 from within estimation whereas it is 0.615 from GMM estimation (Panel B) compared to 2.121 (Table 2, Panel A, column 7): Both estimates are consistent and less than with our baseline results.

Table 4: The effect of health on human capital with alternative health outcomes

	Panel A: Dynamic within estimates					
Independent variables	child mor5 (1)	mat mor (2)	adult mor. fe (3)	adult mor. ma (4)	survi female (5)	survi male (6)
Health outcomes	-0.003***	-0.003***	-0.003***	-0.002***	0.004***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Long-run effect	-0.405***	-0.543***	-0.698***	-0.659***	1.258***	0.863***
of health	(0.048)	(0.153)	(0.178)	(0.229)	(0.364)	(0.288)
Persistence in	0.993***	0.995***	0.996***	0.997***	0.997***	0.997***
education	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	5,926	3,430	6,160	6,160	6,223	6,223
No. of country	141	141	141	141	141	141
	Panel B: GMM estimates					
Health outcomes	-0.004***	-0.004***	-0.004***	-0.004***	0.008***	0.006***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Long-run effect	-0.406 ***	-0.615***	-0.793***	-0.764***	1.740***	1.277***
of health	(0.042)	(0.146)	(0.185)	(0.207)	(0.434)	(0.349)
Persistence in	0.990***	0.994 ***	0.995***	0.995***	0.996***	0.996***
education	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
AR2 test (P-value)	[0.798]	[0.172]	[0.362]	[0.284]	[0.316]	[0.313]
Observations	5,785	3,289	6,017	6,017	6,082	6,082
No. of country	141	141	141	141	141	141

Note: Dependent variable is human capital while independent variables are under-five, maternal, adult female and male mortality rates denoted in columns 1-4. Under-five mortality is the number of under five die per 1,000 live births in a year before reaching five years. Maternal mortality defines as number of pregnant women who dies while pregnant or within 42 days of pregnancy per 100,000 live births. Male and female mortality rates indicate probability of a 15-year old male and female adult who dies before reaching 60 years per 1,000 live births. Columns 5-6 reports female and male survival to age 65 respectively. All variables except human capital are in log form. Robust standard errors against heteroskedasticity and serial correlation at the country level are reported in parentheses. All models include country and year fixed effects. We find different optimal lags for each mortality rate; however, most of them shows six lag as optimal lag used in estimations.
*p <0.10, **p <0.05, ***p <0.01.

Also, we divide our whole sample into subsamples on the basis of four regional regimes: Regions 1-4 indicate estimates of countries of Asia and Pacific region, Sub-Sahara and Africa region, America region (North, Latin America and Caribbean countries), and

European and Central Asia region respectively. Although, modifying the sample, we have obtained a slightly higher estimates from regions 2 and 4, our estimates remains similar to column 1 presented in Table 5.

Table 5: The effect of health on human capital with regimes

	Whole world (1)	Region 1 (2)	Region 2 (3)	Region 3 (4)	Region 4 (5)
	Panel A: Dynamic within estimates				
Health outcomes	0.007***	0.008*	0.004*	0.011*	0.023*
	(0.002)	(0.005)	(0.002)	(0.006)	(0.012)
Long-run effect of health	2.121***	2.258**	3.137	2.585***	3.347***
	(0.535)	(1.070)	(2.121)	(1.165)	(1.144)
Persistence in GDP per capita	0.997***	0.996***	0.999***	0.996***	0.993***
	(0.001)	(0.002)	(0.001)	(0.003)	(0.003)
Observations	6,122	1,640	1,925	1,215	1,342
No. of country	139	39	40	25	35
	Panel B: GMM estimates				
Health outcomes	0.012***	0.008*	0.008***	0.012	0.024*
	(0.004)	(0.005)	(0.002)	(0.008)	(0.012)
Long-run effect of health	2.456***	2.276**	3.058***	2.590**	3.357***
	(0.574)	(1.136)	(1.506)	(1.153)	(1.105)
Persistence in GDP per capita	0.995***	0.997***	0.997***	0.995***	0.993***
	(0.001)	(0.002)	(0.001)	(0.003)	(0.003)
AR2 test (P-value)	[0.316]	[0.165]	[0.110]	[0.528]	[0.627]
Observations	5,982	1,601	1,885	1,190	1,306
No. of country	139	39	40	25	35

Note: Dependent variable is human capita while independent variable is log of total life expectancy at birth. Column 1 reports estimates of whole sample and four subsamples denoted by regions 1-4 presented in columns 2-5 respectively. Regions 1-4 indicate estimates considering countries of Asia and Pacific region, Sub-Sahara and Africa region, America region (North, Latin America and Caribbean countries), and European and Central Asia region respectively. Robust standard errors against heteroskedasticity and serial correlation at the country level are reported in parentheses. All models include country fixed effects.
*p <0.10, **p <0.05, ***p <0.01.

Furthermore, our preferred estimates may be overturned if we include outliers in our model. To check this, we exclude observations that have more and less than three standard deviations from mean (Appendix A, Table A.3, column 2). The cook's distance has been used as well to account for outliers: Where the observations have been omitted, using a common-rule-of-thumb threshold, if they are higher than $(N \times T)/4$ where $(N \times T)$ is total observations (Appendix A, Table A.3, column 3). The estimates from both cases are very similar to our preferred baseline findings.

Finally, since we use Arellano-Bond estimator, the estimates may be biased and inconsistent for instruments proliferation. To address this issue, we reduce sample size by considering truncated lags to 15, 19 and 26 respectively. This alteration of sample size does not change our results and preferred findings from GMM estimator remain similar(Appendix A, Table A.3, columns 5-7). This implies our GMM estimates do not drive for asymptotic or finite sample size.

Overall, we use different panel estimators: The static and dynamic fixed effects estimators as well as Arellano-Bond GMM estimator. Although the static fixed effects estimates are lower than dynamic fixed effects estimates, our preferred within estimates are very similar to estimates of Arellano-Bond GMM estimator when endogeneity of health is addressed with internal instruments. To check robustness our results, we use several time-varying controls both in dynamic within and GMM estimators. This analysis does not include external instruments required to address the exogenous sources of variation in health. Although our findings are consistent with a large number of time period, we will develop our discussion further to uncover asymptotic properties of panel estimators by including external instruments in the model in future.

4 Channels

As discussed earlier, health effects on education attainment work through mechanisms. A large number of papers underline the significance of channels to model between health and human capital (e.g., Ben-Porath, 1967; Ehrlich and Lui, 1991; Zhang and Zhang, 2005; Barro, 1996; Aghion et al., 2010; Kalemli-Ozcan et al., 2000). These authors argue that an improved life expectancy at birth increases saving which is invested in child education and thus human capital formation scales up. More importantly, these investment in acquiring child education serves as coverage of insurance for old age of parents. On the other hand, a better health can reduce fertility by demographic transition with varying lags provided individuals reside in a lower mortality rate environment. Thus parents with improved health prefer quality child over quantity. We use the following model to find intermediate factors through which health works on education:

$$c_{it} = \beta h_{it} + \sum_{l=1}^{q} \delta_l c_{i(t-l)} + \alpha_i + \gamma_t + u_{it} \tag{3}$$

where c denotes channels and all other variables are the same as model 1. In this respect, β conveys the impacts of life expectancy on each channel. δ presents persistence in each channel which is required to find consistent estimates of parameter.

Table 6: The estimates of effect of life expectancy on channels

	Saving	Fertility
	Panel A: Static within estimates	
Health	1.426***	-0.769*
	(0.363)	(0.141)
Observations	4,899	9,917
No. of country	170	183
	Panel B:Dynamic within estimates	
Health	0.474***	-0.033***
	(0.176)	(0.005)
Long-run effect of health	1.322***	-1.439***
	(0.479)	(0.162)
Persistence in outcome	0.642***	0.977***
	(0.034)	(0.002)
Observations	3,664	8,829
No. of country	162	179

Note: The dependent variables are log of saving and log of fertility while independent variable is log of life expectancy at birth. Robust standard errors against heteroskedasticity and serial correlation at the country level are reported in parentheses. All models consider country and year fixed effects.
*p <0.10, **p <0.05, ***p <0.01.

Our estimates using model (3) demonstrates that life expectancy is significantly and positively correlated with saving. For example, using dynamic within estimator, saving rises around 132% in the long-run due to a 1% improvement in life expectancy (Panel B, column 1, Table 6). On the other hand, column 2 of Panel B (Table 6) shows that fertility declines by a 144% if health is improved by a 1% in the long-run. Thus life expectancy works through saving and fertility on human capital.

5 Conclusions

In health, education and welfare field, the relationship between health and education plays an important role to design public policy. The existing literature underscores the uncovering the relationship of life expectancy and human capital as human capital accounts for a significant part of welfare measured by GDP per capital. The large difference in life expectancy across the countries accounts for difference in human capital. The exploration of link between these two variables can help to design policies to promote health and education.

We use an updated yearly longitudinal dataset for the period of 1960 to 2015 for 139 cross-section units covering the entire world. As the number of countries are very large and time period is very long, our dynamic panel data models allow us to find consistent estimates of parameters of interest under stationary process of panel units. The findings from GMM estimation remain similar for asymptotic or finite samples. In a dynamic fixed effects regression, controlling for country fixed effects and dynamics of human capital, we find that there is a significantly positive relationship between life expectancy and human capital. Our results from the preferred specification document that in the long-run human capital increases by about 0.021 by a 1% improvement in life expectancy: On average, if life expectancy goes up by around 20 years (for example, from 1950 to 1970), human capital rises to 1.394 which is large in magnitude. When instrumenting health with internal instruments using GMM estimator, our results are comparable.

This paper also explores channels via which life expectancy affects human capital even though channels have not been tested. We uncover two channels such as saving and fertility. Our results show that improved life expectancy promotes education by increasing saving and decreasing fertility.

References

Acemoglu, D. and Johnson, S. (2007). Disease and development: the effect of life expectancy on economic growth. *Journal of Political Economy*, 115(6):925–985.

Aghion, P., Howitt, P., and Murtin, F. (2010). The relationship between health and growth: when Lucas meets Nelson-Phelps. NBER working paper 15813, National Bureau of Economic Research, Cambridge, MA, USA.

Ando, A. and Modigliani, F. (1963). The “life cycle” hypothesis of saving: Aggregate implications and tests. *The American Economic Review*, 53(1):55–84.

Arellano, M. and Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58(2):277–297.

Baltigi, B. H. (2005). *Econometric Analysis of Panel Data*. John Wiley & Sons, Ltd.

Barro, R. J. (1996). Determinants of economic growth: a cross-country empirical study. NBER working paper 5698, National Bureau of Economic Research, Cambridge, MA, USA.

Barro, R. J. and Lee, J. W. (2013). A new data set of educational attainment in the world, 1950–2010. *Journal of development economics*, 104:184–198.

Ben-Porath, Y. (1967). The production of human capital and the life cycle of earnings. *Journal of political economy*, 75(4, Part 1):352–365.

Bleakley, H. (2007). Disease and development: evidence from hookworm eradication in the American South. *The quarterly journal of economics*, 122(1):73–117.

Cohen, D. and Leker, L. (2014). Health and education: Another look with the proper data. Discussion paper dp9940, Centre for Economic Policy Research, London, UK.

Ehrlich, I. and Lui, F. T. (1991). Intergenerational trade, longevity, and economic growth. *Journal of Political Economy*, 99(5):1029–1059.

Hansen, C. W. (2013). Life expectancy and human capital: Evidence from the international epidemiological transition. *Journal of health economics*, 32(6):1142–1152.

Jayachandran, S. and Lleras-Muney, A. (2009). Life expectancy and human capital investments: Evidence from maternal mortality declines. *The Quarterly Journal of Economics*, 124(1):349–397.

Judson, R. A. and Owen, A. L. (1999). Estimating dynamic panel data models: a guide for macroeconomists. *Economics letters*, 65(1):9–15.

Kalemli-Ozcan, S., Ryder, H. E., and Weil, D. N. (2000). Mortality decline, human capital investment, and economic growth. *Journal of development economics*, 62(1):1–23.

Lorentzen, P., McMillan, J., and Wacziarg, R. (2008). Death and development. *Journal of economic growth*, 13(2):81–124.

Meltzer, D. O. (1992). *Mortality decline, the demographic transition, and economic growth*. PhD thesis, University of Chicago, Department of Economics.

Preston, S. H. (1975). The changing relation between mortality and level of economic development. *Population studies*, 29(2):231–248.

PWT (2019). Pen World Table-PWT 9.1. Report, Groningen Growth and Development Centre, University of Groningen,The Netherlands. Available from: http://databank.worldbank.org/ data//reports.aspx?source=2&country=&series =SH.DYN.MORT&period=https://www.rug.nl/ggdc/productivity/pwt/?lang=en [Accessed: 24 June 2019].

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system gmm in stata. *The stata journal*, 9(1):86–136.

Sachs, J. D. (2002). Macroeconomics and health: investing in health for economic development. *Revista Panamericana de Salud Pública*, 12:143–144.

Schultz, T. W. (1993). The economic importance of human capital in modernization. *Education economics*, 1(1):13–19.

UNDP (2019). Human Development Data. Report, UNITED NATIONS DEVELOPMENT PROGRAMME, New York, USA. Available from: http://hdr.undp.org/en/data [Accessed: 24 June 2019].

Wooldridge, J. M. (2002). *Introductory econometrics: A modern approach*. The MIT Press.

World Bank (2019). World Development Indicators. Report, World Bank, Washington, D.C. Available from: http://databank.worldbank.org/ data//reports.aspx?source=2&country=&series =SH.DYN.MORT&period= [Accessed: 24 June 2019].

Zhang, J. and Zhang, J. (2005). The effect of life expectancy on fertility, saving, schooling and economic growth: theory and evidence. *The Scandinavian Journal of Economics*, 107(1):45–66.

Appendix A: Tables

Table A.1: The effect of health on other education measures

Dependent variables	Human capital (1)	Prep. school enroll. (2)	Prim. school enroll. (3)	Second. school enroll. (4)	Terti. school enroll. (5)	Mean years school (6)	Expec. years school (7)	child. out school. (8)	Adoles. out school. (9)
Health	0.697***	6.492***	1.457***	3.239***	5.862***	9.489***	17.545***	-101.324***	-81.467***
	(0.176)	(0.620)	(0.188)	(0.390)	(0.542)	(1.790)	(2.501)	(10.447)	(19.406)
R-Square	0.608	0.5424	0.324	0.577	0.563	0.288	0.475	0.498	0.410
Observations	6,947	4,883	6,605	5,614	5,024	4,213	4,505	3,787	2,009
No. of country	139	179	182	182	180	181	182	177	159

Note: Dependent variables are human capital, preprimary, primary, secondary and tertiary school enrollments, mean and expected years of schooling, child school drop out and adolescent school drop out are in columns 1-9 respectively. All variables are in log form except human capital, mean and expected years of schooling. Robust standard errors against heteroskedasticity and serial correlation at the country level are reported in parentheses. We consider country and year fixed effects. *p <0.10, **p <0.05, ***p <0.01.

Table A.2: The effects of health on other education measures

	Prep. school enroll. (1)	Prim. school enroll. (2)	Second. school enroll. (3)	Terti. school enroll. (4)	Mean years school (5)	Expec. years school (6)	child. out school. (7)	Adoles. out school. (8)
				Panel A: Dynamic within estimates				
Health	0.695***	0.079***	0.159***	0.466***	0.471***	1.1481***	-7.775***	-7.353
	(0.118)	(0.020)	(0.032)	(0.131)	(0.089)	(0.231)	(2.339)	(9.684)
Long run	7.553***	1.175***	2.748***	7.076***	8.681***	11.962***	-87.620***	-36.326
effect of health	(0.839)	(0.256)	(0.411)	(0.993)	(1.263)	(1.789)	(27.167)	(38.307)
Persistence	0.908***	0.933***	0.942***	0.934***	0.946***	0.904***	0.911***	0.798***
in education	(0.011)	(0.009)	(0.009)	(0.015)	(0.006)	(0.009)	(0.016)	(0.079)
Observations	2,821	4,423	3,044	2,620	3,152	3,441	1,590	578
No. of country	141	173	163	143	176	180	135	78
				Panel B: GMM estimates				
Health	0.930***	0.080***	0.164***	1.048***	0.432***	0.911***	-16.141***	-13.975***
	(0.175)	(0.041)	(0.071)	(0.266)	(0.101)	(0.214)	(5.653)	(12.679)
Long run	6.068***	0.677***	1.441***	8.341***	8.661***	11.145***	-68.799***	-28.776***
effect of health	(0.953)	(0.325)	(0.517)	(0.991)	(1.392)	(1.872)	(24.924)	(25.525)
Persistence	0.847***	0.882***	0.886***	0.874***	0.950***	0.918***	0.765***	0.514***
in Education	(0.019)	(0.020)	(0.016)	(0.023)	(0.007)	(0.009)	(0.043)	(0.075)
AR2 test (p-value)	[0.057]	[0.219]	[0.073]	[0.635]	[0.553]	[0.790]	[0.450]	[0.445]
Observations	2,610	4,152	2,786	2,406	2,974	3,257	1,404	482
No. of country	137	170	159	135	175	178	121	68

Note: The dependent variable are-rather than human capital- preprimary, primary, secondary and tertiary school enrollments, mean and expected years of schooling, child school drop out and adolescent school drop out are in columns 1-8 respectively. All variables are in log form except mean and expected years of schooling. We use our preferred lags in this table: six lags are used as a preferred lags in our analysis. Robust standard errors against heteroskedasticity and serial correlation at the country level are reported in parentheses. All specifications capture country and year fixed effects.
*p <0.10, **p <0.05, ***p <0.01.

Table A.3: The effect of health on human capital

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Health	0.007***	0.008***	0.008***	0.012***	0.013***	0.013***	0.013***
	(0.002)	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.004)
Long-run effect	2.121***	2.199***	2.296***	2.456***	2.921***	2.969***	4.951***
of health	(0.535)	(0.434)	(0.422)	(0.574)	(0.537)	(0.633)	(1.769)
Persistence in	0.997***	0.996***	0.996***	0.995***	0.995***	0.996***	0.997***
GDP per capita	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
AR2 test (P-value)				[0.316]	[0.132]	[0.369]	[0.665]
Observations	6,122	6,479	6,206	5,982	4,735	4,179	3,237
No.instruments				2,772	2,514	2,324	1,956
No. country	139	139	139	139	139	139	123

Note: Dependent variable is human capital while independent variable is log (total life expectancy at birth). The preferred estimates of column 1 is reproduced from column 7 of Table 2. Columns 2-3 present estimates from outliers. Column 4 is repeated from column 7 of Panel B of Table 2. Columns 5-7 report results from alternative GMM truncated lags to 15, 19 and 26 respectively. All models include country and year fixed effects. Six lags are used as a preferred lags in our analysis. Robust standard errors against heteroskedasticity and serial correlation at the country level are reported in parentheses.
*p <0.10, **p <0.05, ***p <0.01.

Appendix B: Figures

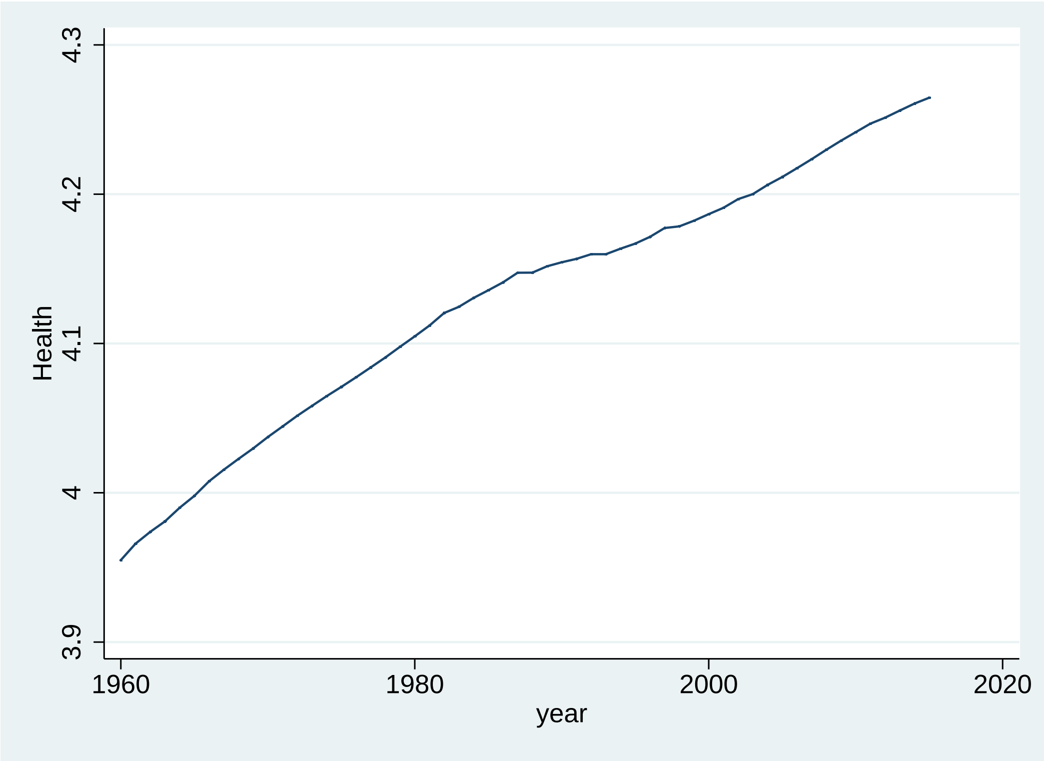

Figure.1: The relationship between the mean of Health (log of life expectancy at birth) and years over 1960-2015.

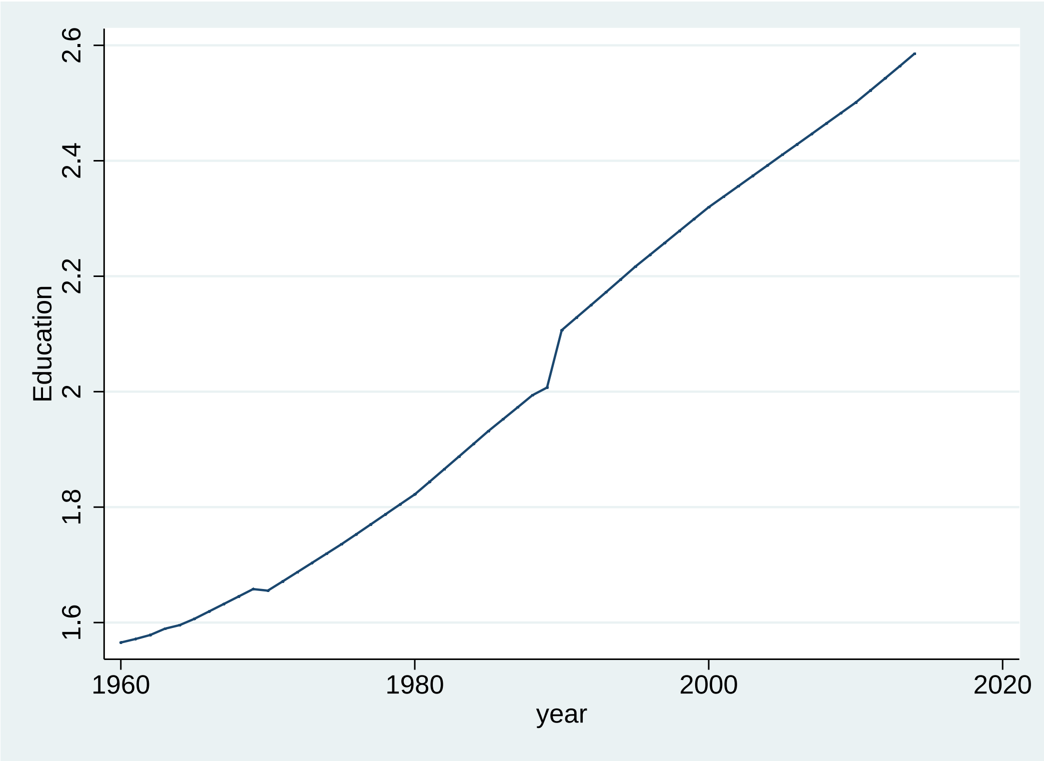

Figure.2: The relationship between mean of Education (Human Capital Index) and years over 1960-2015.

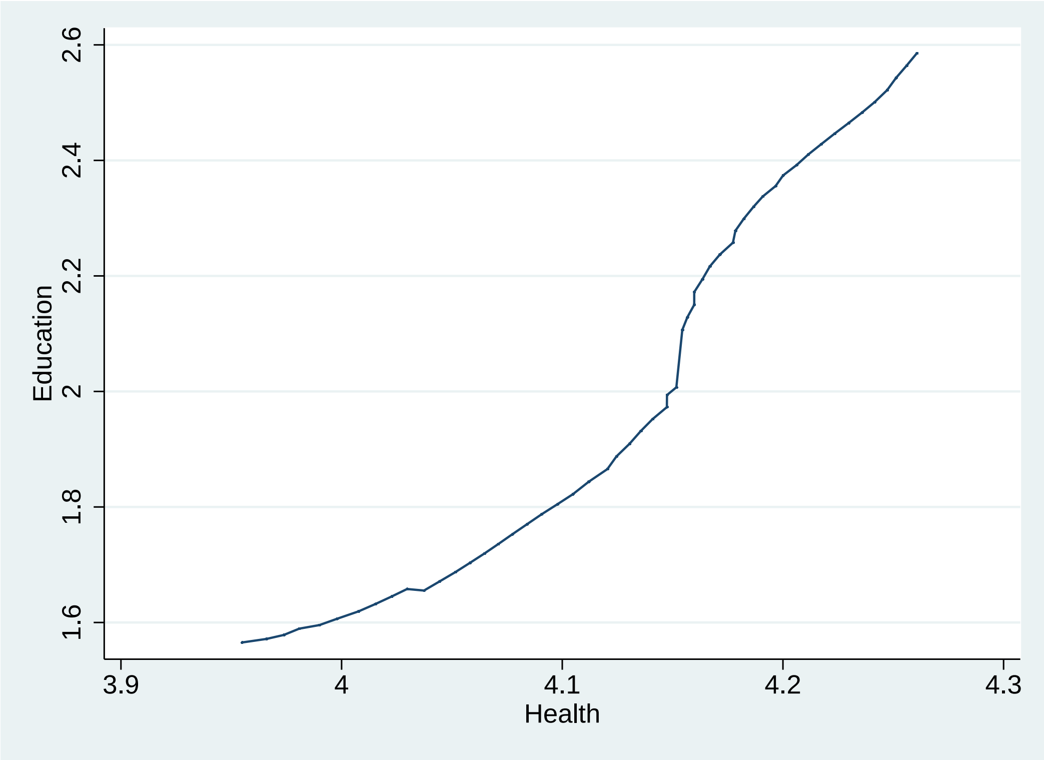

Figure.3: The relationship between the mean of Health (log of life expectancy at birth) and the mean of Education (Human Capital Index) over the period 1960-2015.

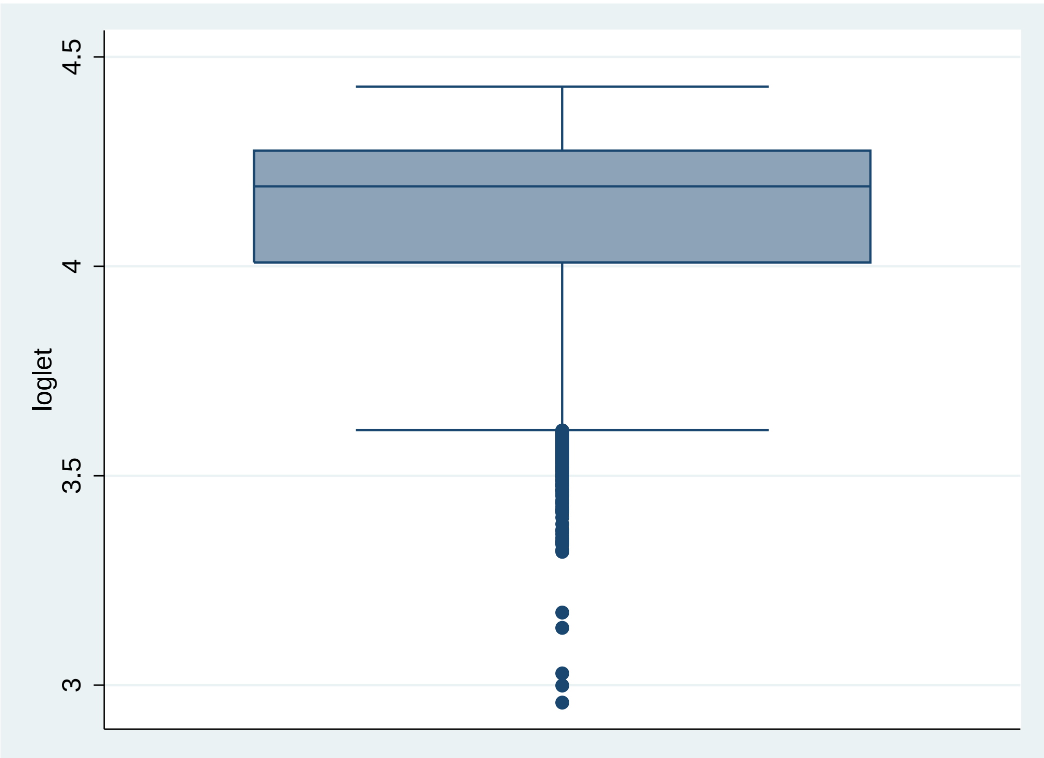

Figure.4: The distribution of log(life expectancy) with box diagram.

Note: loglet denotes the log (Life expectancy at birth).

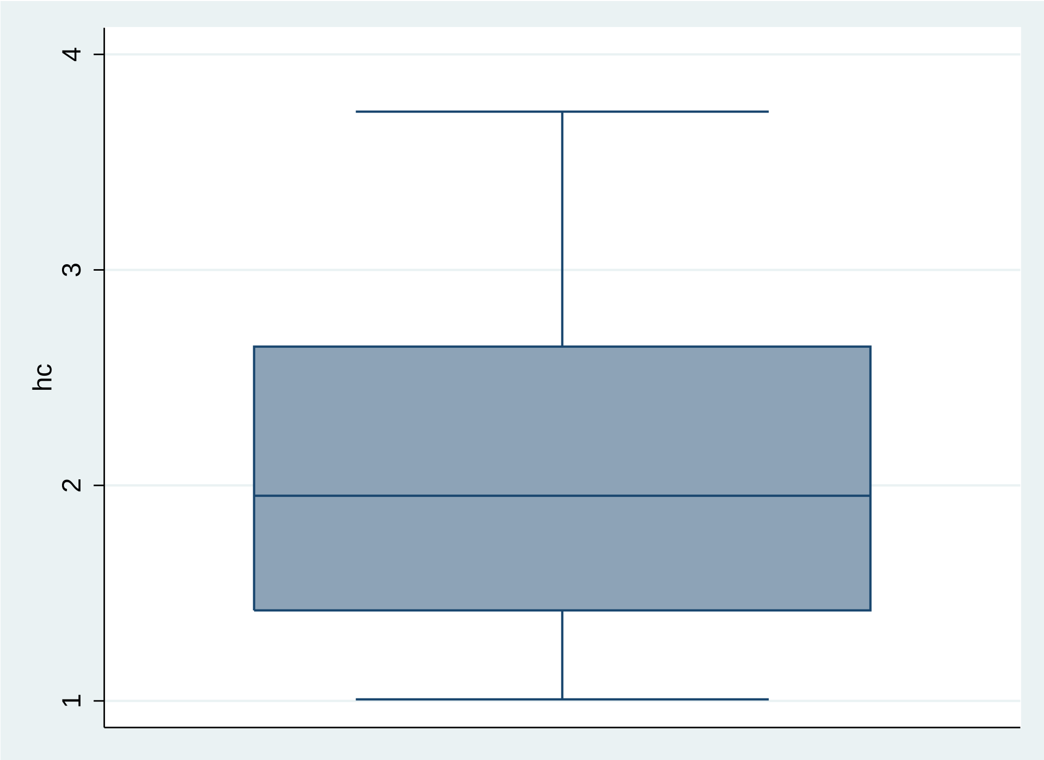

Figure.5: The distribution of Education with box diagram.

Note: hc indicates human capital index.