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# On the Impact of Income per Capita on Health Outcomes: Is Africa Different?

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**Abstract:** This paper examines the link between income per capita, adult life expectancy and mortality rates for children. We estimate a dynamic panel model using data from 128 developing countries and find that all else equal external (i.e., non-country specific) factors have a positive and significant impact on health outcomes, and this effect has increased over time; countries in Sub-Saharan Africa (SSA) have a higher mortality rate and lower life expectancy than non-SSA countries and the effect of income per capita on health outcomes is different for SSA countries.

**Keywords:** Child mortality, Income per capita, Life expectancy, Sub-Saharan Africa

## 1. Introduction

To the extent that income per capita may be interpreted as the summary of the economic conditions in a country, the above quote suggests that per capita income has a causal effect on health outcomes. It is therefore not surprising that the large empirical literature on the determinants of health outcomes typically include GDP per capita as an explanatory variables. The overwhelming results from the literature is summarized in the seminal paper by Pritchett and Summers (1996:863) who note that "wealthier nations are healthier nations" and "gains from rapid economic growth flow into health gains". The idea that income may have a positive effect on health outcomes is plausible, for the simple reason that higher income permits households to spend more on the personal health of the family, which in turn improves the heath of the household. Under this scenario, the influence of a country's own level of income on the country's health outcome will depend on country-specific factors such as education, nutrition and factors that affect the delivery of health-related services. However, the health of a country's residents may also be influenced by exogenous factors. We elaborate on two such factors. The first pertains to the "global public good" aspect of health such as advances in medical technology and the diffusion of health technology. Indeed, the importance of global factors is consistent with the findings of Preston (2007). Using data from 1900, 1930 and 1960, Preston (2007) finds that factors exogenous to a country's level of income accounted for about 84% of the increase in life expectancy during that period. He concludes that the importance of income per capita in explaining health outcomes has diminished over time. Clearly, globalization enhances technological diffusion. As a consequence, it is very likely that in this era of widespread globalization, the positive effect of per capita income on health outcomes observed in previous years may have diminished or completely disappeared in recent years, in which case the GDP per capita may not have a significant impact or at best may have a small impact on health outcomes. The second exogenous factor is "Geography". For example, countries in the tropics, in particular countries in Sub-Saharan Africa (SSA) are more prone to some specific diseases, such as malaria (Bloom and Sachs, 1998).

This paper reassesses the relationship between income per capita and health outcomes. Specifically, we consider four measures of health, two for children and two for adults: under-1 year mortality rate, under-5 year mortality rates, and life expectancy for adult females and males. We answer four questions. All else equal,
(i) How relevant are global factors (i.e., non-country specific factors) in explaining health outcomes? Has the effect of global factors on health outcomes increased over time?
(ii) Do child mortality rates and adult life expectancy for SSA countries vary significantly from that of non-SSA countries?
(iii) Does GDP per capita have a causal impact on health outcomes?
(iv) Is the effect of GDP per capita on health outcomes for SSA countries significantly different from that of non-SSA countries?

To answer these questions, we estimate a dynamic panel model and employ panel data from 128 developing countries over the period 1994-2014. We include $ln$(GDP per capita), $gdpc$, and $gdpc2$ in our regressions to test the non-linear effect of income per capita on health outcomes. We also include a dummy variable, $SSA$, for countries in SSA, as well as the interaction term, $SSA \times gdpc$, to examine whether the relationship between income per capita and health outcomes is different for SSA countries. We find that:
(i) Global factors have a positive and significant impact on health outcomes and that the effect has increased over time;
(ii) Countries in SSA have a higher child mortality rate and lower adult life expectancy compared to countries outside SSA;
(iii) An increase in GDP per capita significantly reduces mortality rates for children and increases adult life expectancy. However, the effect is non-linear: the negative effect on mortality and the positive effect on life expectancy become stronger at higher levels of income, pointing to a divergence in health outcomes;3 and
(iv) The effect of GDP per capita on health outcomes is different for SSA countries. Specifically, the effect on mortality rate is less for SSA countries than non-SSA countries. In contrast, the effect on life expectancy is higher for SSA countries than for countries outside SSA. The results hold after controlling for health expenditure, primary school enrollment and HIV/AIDS prevalence.

The remainder of the paper is organized as follows. Section 2 examines the bivariate relationship between GDP per capita and health outcomes for our sample countries. Section 3 provides a brief literature review and it articulates our contribution to the literature. Section 4 describes the data and the variables employed in the empirical analysis. Section 5 presents the empirical results and Section 6 concludes.

# 2. Preliminary Analysis

The questions posed in the introduction are partly motivated by the data that we employ for the empirical analysis, which comprise of data from 128 developing countries over the period 1994-2014. Specifically, the data provide a glean of the relationship between GDP per capita and the four measures of health outcomes: under 1-year mortality rate, $fmort$ , under 5-years mortality rate, $infmort$, adult female life expectancy, $lifeexpf$ and adult male life expectancy, $lifeexpm$. The data generate four conjectures.

Conjecture 1: Global factors have a significant impact on health outcomes, and the effect has increased over time.

Evidence 1: Figures 1a-1d plot the four measures of health outcomes and income per capita in 1995 and 2014. The graphs show that for a given level of $gdpc$, mortality rates ( $infmort1$, $infmort5$) in 2014 is lower than the mortality rates in 1995 (Figures 1a and 1b) and life expectancy rates ($lifeexpf$ , $lifeexpm$) in 2014 is higher than life expectancy rates in 1995 (Figures 1c and 1d). This suggests that the effect of non-income related factors on health outcomes has increased over time.

Conjecture 2: GDP per capita has a significant and positive effect on health outcomes and the relationship may be quadratic.

Evidence 2: Figures 2a-5b show the scatter plot between $gdpc$ and health outcomes for SSA and non-SSA countries. The graphs show clearly suggest that a higher $gdpc$ is associated with lower mortality rates and a higher life expectancy and that the relationship between $gdpc$ and health outcomes may be quadratic.

Conjecture 3: The relationship between GDP per capita and health outcomes may be different for countries in SSA and non-SSA countries.

Evidence 3: Figures 2a-5b show that the curvature of the scatter plot for $gdpc$ and health outcomes for SSA countries (Figures 2a, 3a, 4a, and 5a) is different from that for non-SSA countries (Figures 2b, 3b, 4b, and 5b). Specifically, the graph for $gdpc$ and child mortality rates is concave for countries in SSA (Figures 2a and 3a), but convex for countries outside SSA (Figures 2b and 3b); and the graph for $gdpc$ and life expectancy is convex for SSA countries (Figures 4a and 5a) but concave for non- SSA countries (Figures 4b and 5b).

A relevant question is whether the relationship between $gdpc$ and health outcomes hypothesized above will hold after controlling for other relevant factors that may affect health outcomes.

# 3. Brief Literature Review

Most of the empirical papers on the determinants of health outcomes include income per capita as one of the explanatory variables. Our literature review revealed 20 papers have included per capita income as an explanatory variable. The notable points are the following. First, Figures 2a-5b suggest that the relationship between $gdpc$ and health outcomes may be quadratic, yet, only one paper, Clark (2011) includes the square of $gdpc$ as an explanatory variable. The remaining papers assume that the relationship between income per capita and health outcomes is linear. Second, only five papers include time dummy variables. This is problematic because the data suggest that time-specific effects may be relevant in explaining health outcomes. Third, only three studies (Klasen, 2006; Scanlan, 2010; Clark, 2011) include HIV/AIDS as an explanatory variable. Controlling for HIV prevalence is important because as noted in UNDP (2005: 10), "HIV/AIDS is a global epidemic and the disease has inflicted the single greatest reversal in human development in modern history." Fourth, the data suggest that SSA is "different". Yet only 4 papers include a dummy variable for SSA (Cornia and Mwabu, 1997; Ranis et.al., 2000; Klasen, 2006 and Clark, 2011). Here, it is important to distinguish between the "intercept" effect and the "slope" effect. Note that including a dummy variable for SSA permits one to test the "intercept effect", i.e., whether health outcomes in SSA countries is significantly different from health outcomes in non-SSA countries. None of the studies include an interaction term between $SSA$ and $gdpc$ to examine the "slope effect" i.e., whether the effect of $gdpc$ on health outcomes is different for countries in SSA. Fifth, similar to many macroeconomic variables, health outcomes are likely to be persistent, i.e., current values of health outcomes are likely to be correlated with previous values of health outcomes. If that is the case, then lagged health outcome should be included as an explanatory variable in the regressions. Yet, only one study includes lagged health as an explanatory variable (Neumayer, 2004). However, the estimations in Neumayer (2004) employ Ordinary Least Squares (OLS).

This is problematic because OLS estimates are biased and inconsistent when a lagged dependent variable is included as an explanatory variable. The last point pertains to the estimation procedures employed in the papers. Specifically, the studies employ OLS, two-stage least squares (2SLS) and random effects estimations. There is also the issue of reverse causality between health outcomes and $gdpc$ . For example higher adult life expectancy may lead to an increase in per capita income (Bloom et. al., 2004 and Cervellati and Sunde, 2011), and lower mortality rates for children may have a positive effect on income per capita (Bhargava et. al., 2001; Lorentzen et. al., 2008). It is important to note that reverse causality and the inclusion of a lagged dependent variable introduce endogeneity and this problem cannot be addressed by OLS, 2SLS or random effects estimations.

This paper makes several contributions to the literature. First, we employ the dynamic panel system General Method of Moments estimator proposed by Blundell and Bond (1998) to addresses the endogeneity and dynamic issues not considered in previous studies. We also include time dummy variables and we control for HIV prevalence. In addition, we include $gdpc$ and the square of $gdpc$ as explanatory variables to allow the effect of $gdpc$ on health outcomes to vary by income. Finally, we include a dummy variable for SSA and interact the SSA dummy variable with $gdpc$ to examine whether health outcomes in SSA countries differ from outcomes in non-SSA countries with regard to the "intercept" and "slope". This is important because several studies have concluded that SSA is unique in that the effect of some socioeconomic and institutional factors are different for SSA countries and non-SSA countries (e.g., Asiedu, 2002; Dalgaard et al., 2004).4 Indeed, examining the "Africa" effect on health outcomes is one of the innovations of the paper. To the best of our knowledge this is the first paper to examine this issue for health outcomes.

For example, Asiedu (2002) shows that the determinants of FDI to SSA is different from the factors that drive FDI to other regions, and the analysis of Dalgaard et al., (2004) suggests that aid may be less effective in SSA countries.

# 4. The Data and the Variables

The empirical analysis employs data from 128 developing countries (45 SSA countries and 83 non- SSA countries) over the period 1994-2014. As it is standard in the literature, the data are averaged over three years. For the dependent variable, we consider 4 measures of health outcomes: under 1-year mortality rate, under 5-year mortality rate, female life expectancy and male life expectancy. Note that the variable of interest is GDP per capita. Following the literature, we use GDP per capita based on purchasing power parity (PPP). The data are in constant 2011 international dollars. The control variables are per capita health expenditure, primary school enrollment and HIV prevalence rate. These variables have been used in previous studies.5 All the data are from the World Development Indicators, published by the World Bank. The summary statistics of the variables are reported in Table 1.

# 5. Estimation Results

We use the two-step GMM estimator to estimate a variant of the equation:

where $i$ refers to countries, $t$ to time, health is a measure of health outcome, $SSA$ takes on value one if the country is located in SSA and zero otherwise, $SSA \times gdpc$ is the interaction term, $Z$ is a vector of control variables, $P$ is a vector of dummy variable that takes on value one in period $t$, and $\theta i$ is the country-specific effect.

Each regression includes a dummy variable for $SSA$, time dummy variables and a lagged dependent variable. The other control variables are included incrementally. Specifically, Column (1) and (4) controls for income per capita, Column (2) and (5) includes health expenditure and primary school enrollment and Column (3) and (6) controls for HIV prevalence. The results reported in Column (3) and (6) is our preferred specification, where all the control variables are included. Question 1. How relevant are global factors in explaining health outcomes? Has the effect of these factors on health outcomes increased over time?

We considered other explanatory variables that have been used in previous studies, including measures of income inequality, gender inequality, access to safe water, degree of urbanization, institutional quality, etc, however, the variables did not display a consistent relationship after controlling for per capita health expenditure, primary school enrollment and HIV prevalence.

The regressions include six time dummy variables, 1997-99, 2000-02, 2003-05, 2006-08, 2009-11, 2012-14, and the reference period is 1994-96. The parameter of interest is the estimated coefficient of the time dummy variable, $\lambda t$. Note that $\lambda t$ is significant at the 1% level in all the 20 regressions (Tables 2, 3, 5 and 6). In addition, $\lambda t$ is negative for all the 10 mortality regressions for children (Tables 2 and 5) and positive for all the 10 life expectancy regressions for adults (Tables 3 and 6), and for each specification, the magnitude of $\lambda t$ increases as the time periods increase. These results suggest that global factors have a positive and significant impact on health outcomes and that the effect has increased over time. More importantly, the results imply that country-specific factors, including GDP per capita, may have become less relevant in explaining the variation in health outcomes across country and within country.

Question 2. Do child mortality rates and adult life expectancy for countries in SSA vary significantly from the mortality rates and life expectancy of countries outside SSA?
The estimated coefficient of the SSA dummy variable, $\hat{\varphi}$ , is significant at the 1% level in all the regressions. Furthermore, $\hat{\varphi}$ is positive for the mortality regressions (Table 2) and negative for the life expectancy regressions (Table 3). This suggests that overall, mortality rate is higher and life expectancy is lower in SSA countries than non-SSA countries. For example, all else equal, the under 1-year mortality rate is about 0.459 percentage points higher for SSA countries than non-SSA countries (Column 3 of Table 2), and the under 5-years mortality rate is about 0.505 percentage points higher for SSA countries (Column 6 of Table 2). There is a gap for life expectancy, however, the gap reduces significantly when one controls for HIV/AIDS. Specifically, the gap shrinks from 0.1698 to 0.0674 percentage points for females (Columns 2 and 3 of Table 3), and it declines from 0.1642 to 0.0707 for males (Columns 4 and 5 of Table 3). This result clearly underscores the importance of controlling for HIV/AIDS. In addition, it reflects the adverse effect of the HIV epidemic on adult life expectancy.

Question 3. Does GDP per capita have a direct causal impact on health outcomes?
To answer this question, we estimate Equation 1 without the interaction term, $SSA \times gdpc$. Note that $\partial health/\partial gdpc = \alpha + 2\beta \times gdpc$ , and $\alpha$ and $\beta$ are significant at the 1% level in all the regressions (Tables 2 and 3). In order to keep the paper focused and also to conserve on space, the discussion will focus on the results for under 1-year mortality rate and life expectancy for females. The results for under 5-years mortality rate and male life expectancy are qualitatively similar and are available upon request.

The estimated marginal effect of $gdpc$ for $infmort1$ (Column 3 of Table 2) and $lifeexpf$(Column 3 of Table 3) are given by equation 14 and equation 15, respectively:

The mean of $gdpc$ for the sample is 8.32 (see Table 1). Thus, our results imply that all else equal, a 1% in GDP per capita in the average country will reduce $infmort1$ by about 26.4% in the short-run and by about 69.4% in the long-run. A similar increase in GDP per capita is expected to raise $lifeexpf$ by 18% and 55% in the short-run and long-run, respectively. To further elucidate the discussion, we compute the average of GDP per capita, $\overline{gdpc}$ , over the sample period, 1994-2014, for each country and we evaluate the estimated value of $\partial health/\partial gdpc$ at reasonable values of $\overline{gdpc}$. Specifically, we evaluate $\hat{\alpha} + 2\beta \times \overline{gdpc}$ at the 10th, 25th, 50th, 75th and the 90th percentile of $\overline{gdpc}$ for the $infmort1$ and $lifeexpf$ regressions. The 10th, 25th, 50th, 75th and the 90th percentile correspond to the value of $\overline{gdpc}$ for Sierra Leone, Haiti, Bolivia, Ecuador and Romania, respectively.

The results reported in Table 4 show that income per capita significantly reduces mortality rates and increases life expectancy. However, the effect is non-linear: the positive effect is stronger at higher levels of income, pointing to a divergence in health outcomes. This result contrasts with Clark (2011), who also concludes that the effect of GDP per capita is nonlinear and it improves health outcomes, however, the marginal effect declines with income for life expectancy (convergence) but increases with infant mortality rates (divergence).

Question 4. Does the effect of GDP per capita on health outcomes for countries in SSA differ significantly from the effect for non-SSA countries?

Here we estimate equation (1) and the parameter of interest is the estimated coefficient of $SSA \times gdpc$ , $\delta$. The regressions for mortality rate and life expectancy are reported in Tables 5 and 6, respectively. Note that $\delta$ is significant at the 1% level in all the regressions, suggesting that the effect of income per capita on health outcomes is significantly different for SSA countries. In addition, $\delta$ is positive for both the mortality and life expectancy regressions. This implies that the positive effect of GDP per capita on mortality rate is less for SSA countries, however, the effect on life expectancy is higher for SSA countries than for countries outside SSA. For example, all else equal, a 1% increase in income per capita reduces under 1-year mortality rate by about 0.1128 percentage points more in non- SSA countries than SSA countries (Column 2 of Table 5). In contrast a similar change raises female life expectancy by 0.0256 percentage points more in SSA countries than non-SSA countries (Column 2 of Table 6).

We now turn our attention to the other explanatory variables. Health care expenditure and school enrollment have a positive impact on health outcomes and HIV/AIDS prevalence has a negative effect. In addition, the estimated coefficient of lagged health, $\hat{\rho}$, is positive and significant in all the regressions, suggesting that health outcomes are persistent. Indeed this underscores the importance of including lagged health as an explanatory variable in the regressions.

# 6. Conclusion

This paper has examined the link between GDP per capita, adult life expectancy and mortality rates for children. We find that:
(i) Global factors (i.e., non country-specific factors) have a positive and significant impact on health outcomes, and this effect has increased over time;
(ii) Countries in SSA have a higher mortality rate and lower life expectancy than countries outside SSA;
(iii) An increase in GDP per capita improves health outcomes and the effect is stronger at higher levels of income; and
(iv) The effect of GDP per capita on health outcomes is different for SSA countries.

There are four main policy implications to be drawn from the findings of the paper. First, as rising per capita GDP has been associated with better health outcomes for children as well as adults, policies that translate into increasing per capita income would be associated with inclusive health benefits. Second, the significance of the impact of other control variables (health expenditures, school enrollment and HIV prevalence) on health outcomes suggests that policy interventions in other areas are important for healthier populations irrespective of the level of income per capita. Third, the result that SSA is "different" suggest that the region would benefit from specific interventions beyond the ones that could be envisaged for other developing areas. The paper's findings suggest that controlling for all relevant factors, populations in the SSA region face location-related health challenges that translate into poorer health outcomes. The geographic location in malaria-prevalent or drought-prone areas makes populations vulnerable to malnutrition and poor health from tropical diseases and other diseases non-existent in non-SSA regions. Finally, there is a need for more investments in health related research, foreign aid in health (private and public) and efforts should be made to diffuse the results globally---in particular to countries in SSA since they have worse health outcomes. Indeed, several papers (Mishra and Newhouse, 2009; Ndikumana and Pickbourn, 2013) have found that aid in health has an impact on health outcomes in recipient countries.

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**Figure 1a: Mortality rate, under 1 year and Per capita income for year 1995 and 2014**

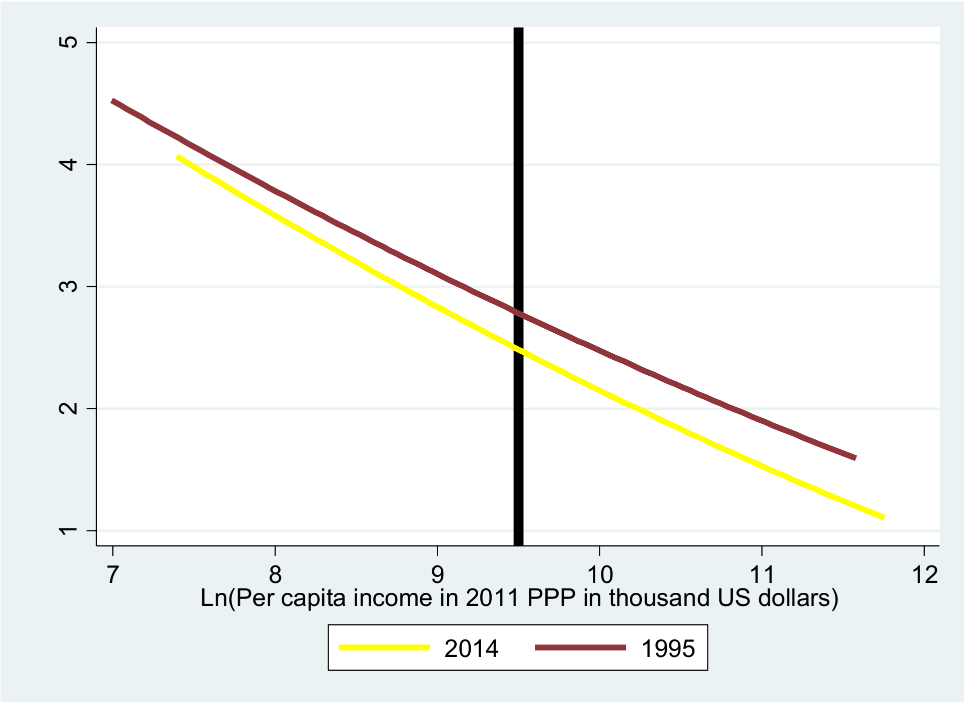



**Figure 1b: Mortality rate, under 5 years and Per capita income for year 1995 and 2014**

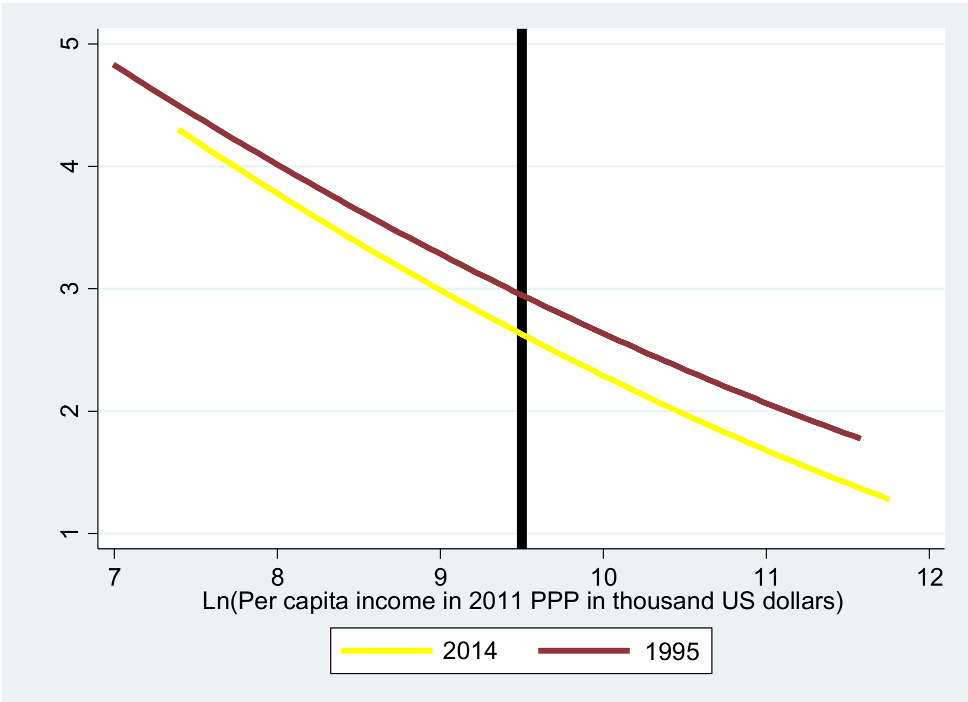



**Figure 1c: Female life expectancy and Per capita income for year 1995 and 2014**

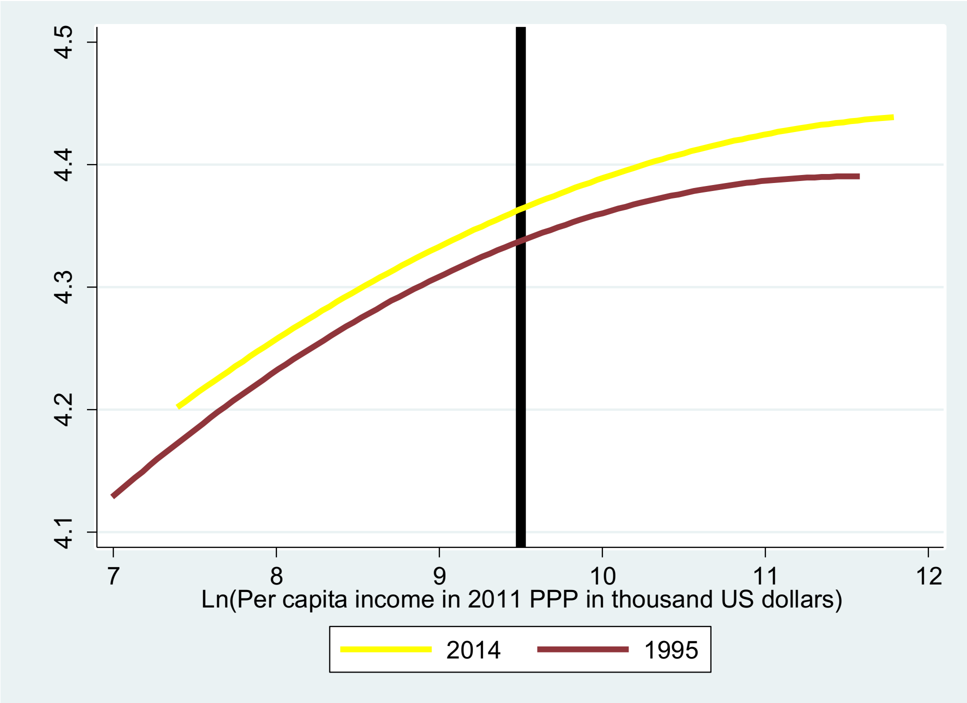



**Figure 1d: Male life expectancy and Per capita income for year 1995 and 2014**

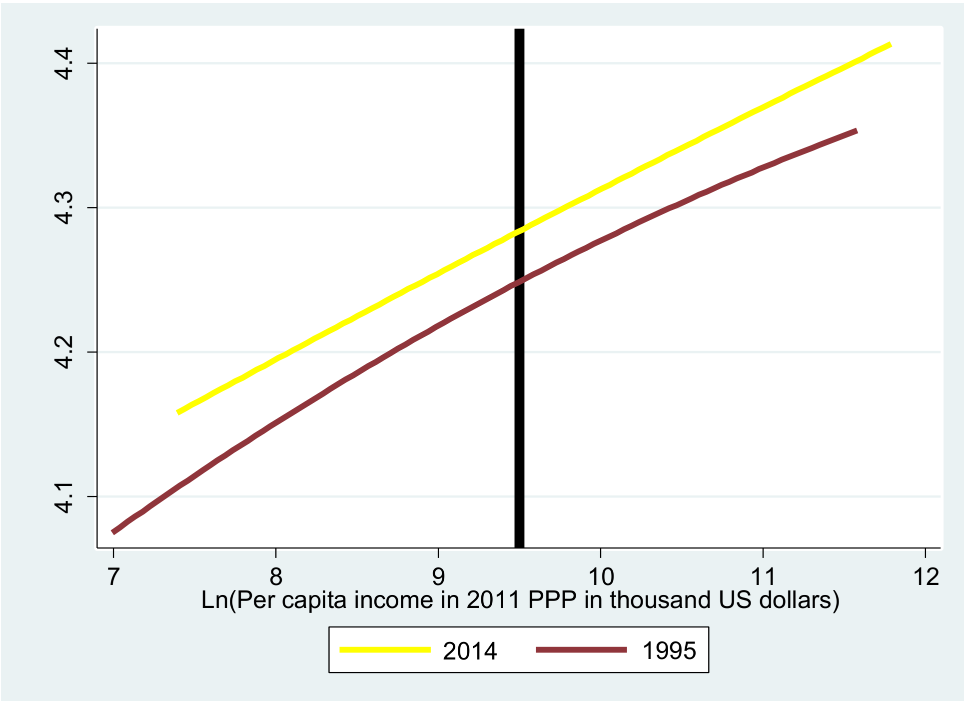
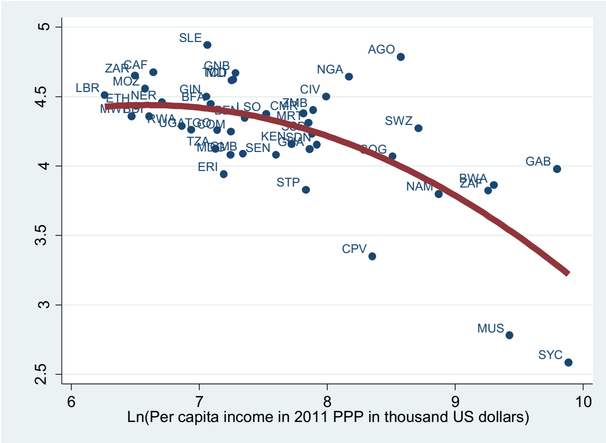



**Figure 2a**
**Mortality rate, under 1 year and Per capita income for 45 countries <u>in SSA</u>, averaged 1994-2014**

**Figure 2b**
**Mortality rate, under 1 year and Per capita income for 83 countries <u>outside SSA</u>, averaged 1994-2014**



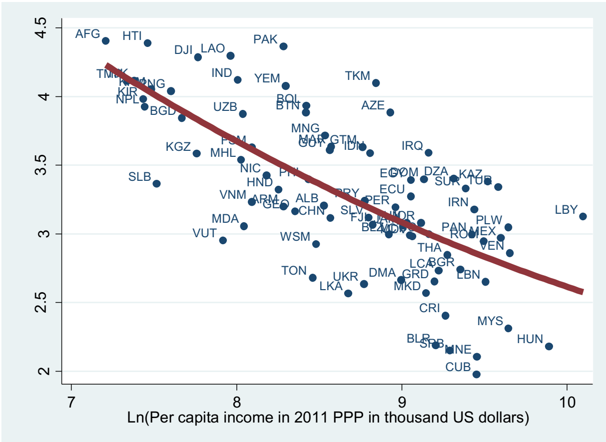
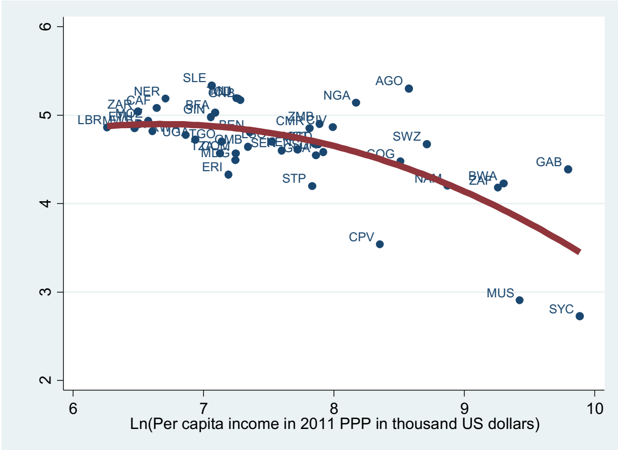




**Figure 3a**
**Mortality rate under- 5 years and Per capita income for 45 countries <u>in SSA</u>, averaged 1994-2014**

**Figure 3b**
**Mortality rate under-5 years and Per capita income for 83 countries <u>outside SSA</u>, averaged 1994-2014**



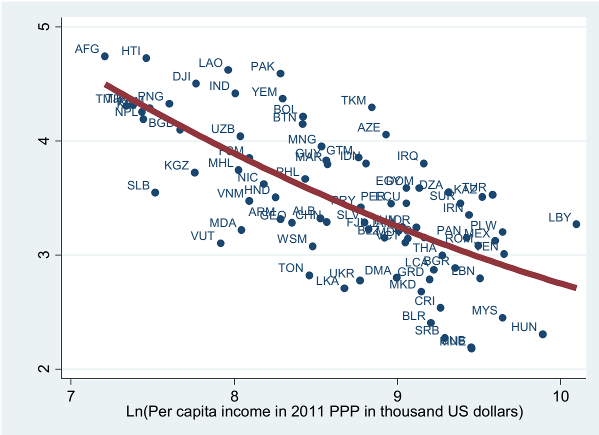
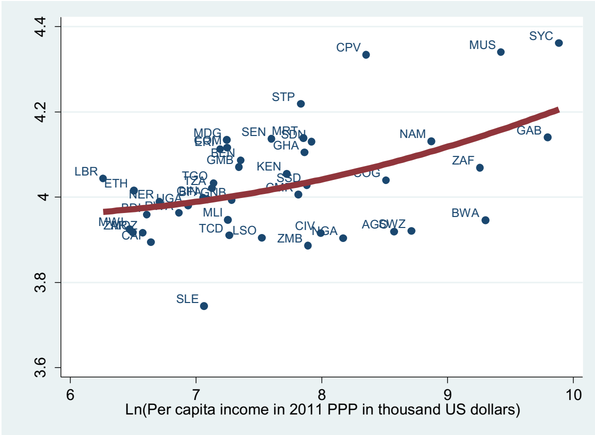




**Figure 4a**
**Female life expectancy and Per capita income for 45 countries <u>in SSA</u>, averaged 1994-2014**

**Figure 4b**
**Female life expectancy and Per capita income for 83 countries <u>outside SSA</u>, averaged 1994-2014**



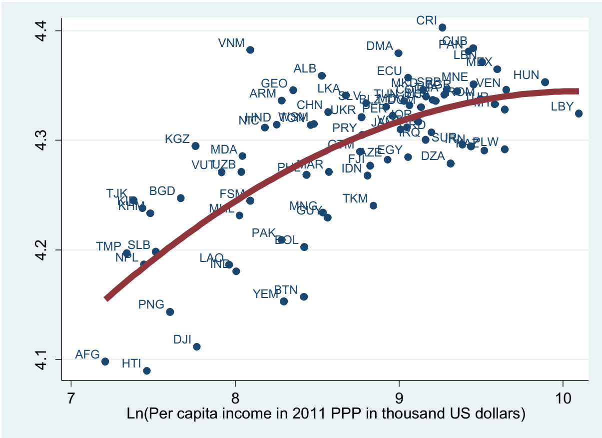
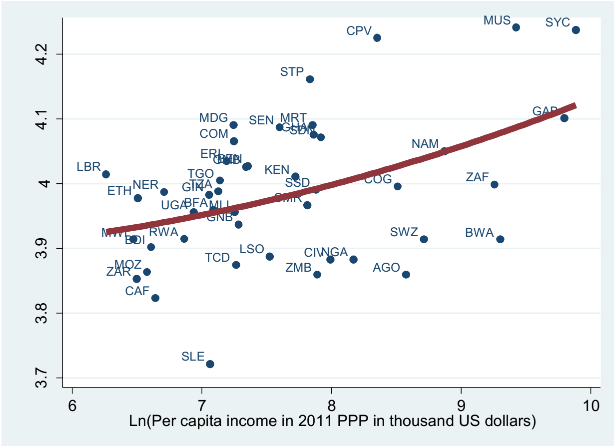




**Figure 5a**
**Male life expectancy and per capita income for 45 countries <u>in SSA</u>, averaged 1994-2014**

**Figure 5b**
**Male life expectancy and per capita income for 83 countries <u>outside SSA</u>, averaged 1994-2014**


Ln(Per capita income in 2011 PPP in thousand US dollars)

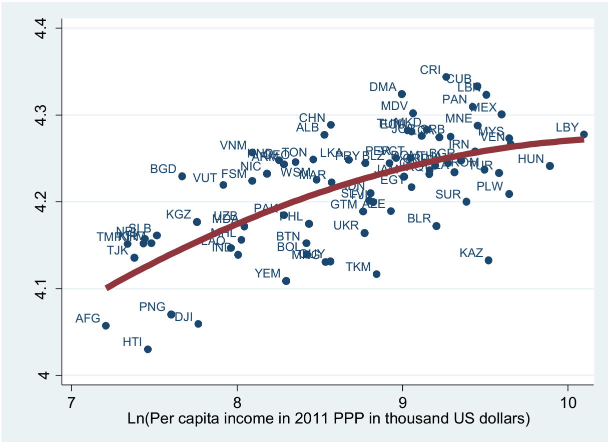

Ln(Per capita income in 2011 PPP in thousand US dollars)

Table 1: Summary Statistics

| | Full sample | | SSA sample | | Non-SSA sample | |
|---|---|---|---|---|---|---|
| Variables | Mean | Std. Dev. | Mean | Std. Dev | Mean | Std. Dev. |
| | | | | | | |
| *ln* (under 1yr mortality rate) | 3.6 | 0.72 | 4.2 | 0.49 | 3.27 | 0.61 |
| *ln* (under 5yr mortality rate) | 3.87 | 0.84 | 4.63 | 0.58 | 3.45 | 0.65 |
| *ln* (life expectancy, female) | 4.2 | 0.16 | 4.03 | 0.14 | 4.29 | 0.07 |
| *ln* (life expectancy, male) | 4.13 | 0.14 | 3.99 | 0.13 | 4.21 | 0.07 |
| *ln* (GDP per capita) | 8.32 | 0.93 | 7.65 | 0.91 | 8.7 | 0.71 |
| *ln* (school enrollment, female) | 4.27 | 1.02 | 4.12 | 1.11 | 4.36 | 0.95 |
| *ln* (school enrollment, male) | 4.34 | 1.01 | 4.25 | 1.12 | 4.4 | 0.95 |
| *ln* ( health expenditure) | 5.08 | 1.04 | 4.4 | 0.97 | 5.45 | 0.87 |
| *ln* (HIV prevalence, female) | 0.59 | 0.69 | 1.09 | 0.78 | 0.2 | 0.2 |
| *ln* (HIV prevalence, male) | 0.45 | 0.5 | 0.76 | 0.6 | 0.21 | 0.18 |

Table 2: Direct effect GDP per capita on mortality rate of children

| | Under 1 year | | | Under 5 years | | |
|---|---|---|---|---|---|---|
| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) |
| | | | | | | |
| ln (Mortality rate), lagged | 0.7048*** | 0.6689*** | 0.6835*** | 0.6520*** | 0.6259*** | 0.6193*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| SSA | 0.5663*** | 0.5494*** | 0.4588*** | 0.7107*** | 0.6840*** | 0.5053*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| ln ( GDP per capita), *gdpc* | 0.1289*** | 0.1668*** | 0.1439*** | 0.3561*** | 0.4443*** | 0.5226*** |
| | (0.000) | -0.001 | (0.000) | (0.000) | (0.000) | (0.000) |
| *gdpc*×*gdpc* | -1.5245*** | -1.9551*** | -1.5956*** | -3.2270*** | -4.1415*** | -4.4521*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| ln (Education, female) | | -0.0011** | 0.0006** | | -0.0032*** | -0.0024*** |
| | | -0.032 | -0.043 | | (0.000) | (0.000) |
| ln (Health expenditure) | | -0.0250*** | -0.0247*** | | -0.0207*** | -0.0382*** |
| | | (0.000) | (0.000) | | (0.000) | (0.000) |
| ln (HIV prevalence, female) | | | 0.0515*** | | | 0.1169*** |
| | | | (0.000) | | | (0.000) |
| 1997-1999 | -0.0225*** | -0.0221*** | -0.0280*** | -0.0273*** | -0.0239*** | -0.0330*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2000-2002 | -0.0626*** | -0.0589*** | -0.0738*** | -0.0802*** | -0.0736*** | -0.0907*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2003-2005 | -0.1071*** | -0.0938*** | -0.1157*** | -0.1380*** | -0.1227*** | -0.1444*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2006-2008 | -0.1436*** | -0.1231*** | -0.1441*** | -0.1902*** | -0.1667*** | -0.1843*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2009-2011 | -0.1737*** | -0.1507*** | -0.1674*** | -0.2355*** | -0.2085*** | -0.2218*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2012-2014 | -0.1848*** | -0.1628*** | -0.1737*** | -0.2613*** | -0.2339*** | -0.2459*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | 3.0445*** | 3.9040*** | 3.2669*** | 5.0064*** | 6.4339*** | 6.5641*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Hansen J test (p-value)[1] | 0.0025 | 0.2021 | 0.1367 | 0.0053 | 0.1566 | 0.0731 |
| Serial correlation test (p-value)[2] | 0.4142 | 0.698 | 0.219 | 0.7618 | 0.8401 | 0.5124 |
| No. of observations | 808 | 808 | 624 | 808 | 808 | 624 |
| No. of countries, *n* | 128 | 128 | 98 | 128 | 128 | 98 |
| No of Instruments, *i* | 86 | 81 | 82 | 86 | 81 | 82 |
| Instrument ratio, $r=n/i$ | 1.49 | 1.58 | 1.19 | 1.49 | 1.58 | 1.19 |
| P-values in parentheses *** p<0.01, ** p<0.05, * p<0.1 | | | | | | |
| [1] The null hypothesis is that the instruments are not correlated with the residuals. | | | | | | |
| [2] The null hypothesis is that the errors in the first difference regression exhibits no second order serial correlations. | | | | | | |

Table 3: Direct effect of GDP per capita on adult life expectancy

| | Adult Female | Adult Male |
|---|---|---|

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | | | | | | |
| *ln*(Life expectancy) lagged | 0.7165*** | 0.6715*** | 0.6728*** | 0.7262*** | 0.6801*** | 0.6787*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *SSA* | -0.1657*** | -0.1698*** | -0.0674*** | -0.1583*** | -0.1642*** | -0.0707*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *ln* ( GDP per capita), *gdpc* | -0.2095*** | -0.1884*** | -0.1543*** | -0.1654*** | -0.1432*** | -0.0857*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *gdpc*×*gdpc* | 1.3194*** | 1.2270*** | 1.0938*** | 0.9482*** | 0.8494*** | 0.5212*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *ln* (Education, female) | | 0.0029*** | 0.0024*** | | 0.0047*** | 0.0035*** |
| | | (0.000) | (0.000) | | (0.000) | (0.000) |
| *ln* (Health expenditure), *lhealth* | | 0.0306*** | 0.0361*** | | 0.0157*** | 0.0340*** |
| | | (0.000) | (0.000) | | (0.000) | (0.000) |
| *lhealth*×*lhealth* | | -0.0037*** | -0.0029*** | | -0.0023*** | -0.0030*** |
| | | (0.000) | (0.000) | | (0.000) | (0.000) |
| *ln* (HIV prevalence, female) | | | -0.0492*** | | | -0.0597*** |
| | | | (0.000) | | | (0.000) |
| 1997-1999 | 0.0064*** | 0.0059*** | 0.0057*** | 0.0101*** | 0.0084*** | 0.0088*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2000-2002 | 0.0131*** | 0.0126*** | 0.0077*** | 0.0158*** | 0.0143*** | 0.0105*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2003-2005 | 0.0227*** | 0.0233*** | 0.0122*** | 0.0243*** | 0.0246*** | 0.0152*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2006-2008 | 0.0364*** | 0.0375*** | 0.0190*** | 0.0382*** | 0.0392*** | 0.0230*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2009-2011 | 0.0496*** | 0.0520*** | 0.0276*** | 0.0515*** | 0.0536*** | 0.0316*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| 2012-2014 | 0.0500*** | 0.0559*** | 0.0280*** | 0.0506*** | 0.0574*** | 0.0325*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | 0.1891*** | 0.3295*** | 0.2739*** | 0.5423*** | 0.7222*** | 0.8730*** |
| | (0.000) | (0.000) | -0.005 | (0.000) | (0.000) | (0.000) |
| Hansen J test (p-value) | 0.0052 | 0.0037 | 0.206 | 0.0052 | 0.0037 | 0.1264 |
| Serial correlation test (p-value) | 0.2415 | 0.1403 | 0.0746 | 0.2397 | 0.1387 | 0.05 |
| No. of observations | 785 | 785 | 622 | 785 | 785 | 622 |
| No. of countries, *n* | 127 | 127 | 98 | 127 | 127 | 98 |
| No of Instruments, *i* | 86 | 82 | 83 | 86 | 82 | 83 |
| Instrument ratio, *r=n/i* | 1.48 | 1.55 | 1.18 | 1.48 | 1.55 | 1.18 |

Table 4: $\partial health/\partial gdpc = \alpha + 2\beta \times gdpc$, evaluated at various values of $gdpc$

| Percentile | Value of | Corresponding | Under 1-year mortality | Life expectancy, female |
|---|---|---|---|---|
| of *gdpc* | *gdpc* | country | $\alpha$= 0.1439; $\beta$=-1.5956 | $\alpha$= -1.543; $\beta$=1.0938 |

| | | | | |
|---|---|---|---|---|
| 10th | 7.062 | Sierra Leone | -22.392***(0.000) | 15.294***(0.000) |
| 25th | 7.603 | Haiti | -24.117***(0.000) | 16.477***(0.000) |
| 50th | 8.391 | Bolivia | -26.633***(0.000) | 18.202***(0.000) |
| 75th | 9.117 | Ecuador | -28.951***(0.000) | 19.791***(0.000) |
| 90th | 9.488 | Romania | -30.134***(0.000) | 20.602***(0.000) |
| Notes: *gdpc* is natural log of the average of GDP per capita from 1994-2014. | | | | |

Table 5: The interaction effect of GDP per capita and SSA on mortality rate of children

| | Under 1 year | | Under 5years | |
|---|---|---|---|---|
| | No HIV | Include HIV | No HIV | Include HIV |
| VARIABLES | (1) | (2) | (3) | (4) |

| | | | | |
|---|---|---|---|---|
| *ln* (Mortality rate), lagged | 0.6458*** | 0.6577*** | 0.5974*** | 0.5985*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *SSA* | -0.6287*** | -0.4859*** | -0.8973*** | -0.6901*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *SSA* × *gdpc* | 0.1415*** | 0.1128*** | 0.1868*** | 0.1430*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *ln* ( GDP per capita), *gdpc* | 0.5221*** | 0.4018*** | 0.9671*** | 0.8643*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *gdpc*×*gdpc* | -5.1439*** | -4.0552*** | -8.8876*** | -7.6618*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *ln* (Education, female) | -0.0014** | 0.0002 | -0.0037*** | -0.0026*** |
| | -0.018 | -0.556 | (0.000) | (0.000) |
| *ln* (Health expenditure) | -0.0273*** | -0.0265*** | -0.0263*** | -0.0432*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *ln* (HIV prevalence, female) | | 0.0572*** | | 0.1172*** |
| | | (0.000) | | (0.000) |
| 1997-1999 | -0.0214*** | -0.0265*** | -0.0217*** | -0.0309*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2000-2002 | -0.0582*** | -0.0720*** | -0.0677*** | -0.0860*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2003-2005 | -0.0958*** | -0.1161*** | -0.1180*** | -0.1414*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2006-2008 | -0.1267*** | -0.1440*** | -0.1628*** | -0.1805*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2009-2011 | -0.1564*** | -0.1695*** | -0.2069*** | -0.2194*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2012-2014 | -0.1715*** | -0.1792*** | -0.2352*** | -0.2449*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | 7.8243*** | 6.4614*** | 12.3139*** | 10.6506*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Hansen J test (p-value) | 0.2355 | 0.1384 | 0.1737 | 0.0484 |
| Serial correlation test (p-value) | 0.7888 | 0.1984 | 0.7512 | 0.4451 |
| No. of observations | 808 | 624 | 808 | 624 |
| Number of countries, *n* | 128 | 98 | 128 | 98 |
| No of Instruments, *i* | 82 | 83 | 82 | 83 |
| Instrument ratio, *r=n/i* | 1.56 | 1.18 | 1.56 | 1.18 |

Table 6: The interaction effect of GDP per capita and *SSA* on adult life expectancy.

| | Adult Female | | Adult Male | |
|---|---|---|---|---|
| | No HIV | Include HIV | No HIV | Include HIV |
| VARIABLES | (1) | (2) | (3) | (4) |
| | | | | |
| *ln* (Life expectancy), lagged | 0.6739*** | 0.6818*** | 0.6796*** | 0.6858*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |

| | | | | |
|---|---|---|---|---|
| *SSA* | -0.2992*** | -0.2752*** | -0.2322*** | -0.2564*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *SSA×gdpc* | 0.0156*** | 0.0256*** | 0.0083*** | 0.0227*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *ln* ( GDP per capita), *gdpc* | -0.1485*** | -0.0625*** | -0.1261*** | -0.0104 |
| | (0.000) | (0.000) | (0.000) | -0.516 |
| *gdpc×gdpc* | 0.8409*** | 0.2285* | 0.6789*** | -0.2011 |
| | (0.000) | -0.076 | (0.000) | -0.114 |
| *ln* (Education) | 0.0027*** | 0.0019*** | 0.0046*** | 0.0030*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *ln* (Health expenditure), *lhealth* | 0.0307*** | 0.0387*** | 0.0155*** | 0.0361*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *lhealth × lhealth* | -0.0038*** | -0.0033*** | -0.0024*** | -0.0032*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| *ln* (HIV prevalence) | | -0.0514*** | | -0.0617*** |
| | | (0.000) | | (0.000) |
| 1997-1999 | 0.0063*** | 0.0063*** | 0.0085*** | 0.0090*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2000-2002 | 0.0134*** | 0.0093*** | 0.0146*** | 0.0115*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2003-2005 | 0.0246*** | 0.0144*** | 0.0251*** | 0.0165*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2006-2008 | 0.0394*** | 0.0217*** | 0.0400*** | 0.0245*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2009-2011 | 0.0539*** | 0.0300*** | 0.0543*** | 0.0326*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| 2012-2014 | 0.0578*** | 0.0300*** | 0.0582*** | 0.0334*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Constant | 0.8083*** | 1.3013*** | 0.9447*** | 1.7436*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Hansen J test (p-value) | 0.004 | 0.2144 | 0.0041 | 0.2192 |
| Serial correlation test (p-value) | 0.1467 | 0.0797 | 0.1497 | 0.0652 |
| No. of observations | 785 | 622 | 785 | 622 |
| No. of countries, *n* | 127 | 98 | 127 | 98 |
| No of Instruments, *i* | 83 | 84 | 83 | 84 |
| Instrument ratio, *r=n/i* | 1.53 | 1.17 | 1.53 | 1.17 |