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The Role of Health in Economic Development

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Abstract

The role of health in economic development is analyzed via two channels: the direct labor productivity effect and the indirect incentive effect. The labor productivity hypothesis asserts that individuals who are healthier have higher returns to labor input. This is well tested in the empirical literature with mixed conclusions. The incentive effect is borne of the theoretical literature, and individuals who are healthier and have a greater life expectancy will have the incentive to invest in education as the time horizon over which returns can be earned is extended. Education is the driver of economic growth, and thus health plays an indirect role. Accounting for the simultaneous determination of the key variables – growth, education, fertility – the results show that the indirect effect of health is positive and significant. Without recognition of the indirect role of health the economic benefits of health improvements are underestimated.

1 Introduction

To enjoy good health and longevity is fundamental to the human experience. Healthy people are more vibrant, energetic, and have a more positive outlook on life. These characteristics not only translate to a positive influence on the social infrastructure, but also affect economic development. The aim of this paper is to show that health does have a positive and significant effect on economic growth.

Contrary to the findings in this paper, Acemoglu and Johnson (2006) assert that interventions aimed at health improvements have been highly effective over the past century, but these improvements and divergent health standards are not responsible for explaining cross country differences in economics growth.

As in Acemoglu and Johnson (2006), the empirical studies to date have focused on the direct labor productivity effects of health on economic growth. The inclusion of labor augmenting health capital, typically proxied for by life expectancy at birth, in the economic growth equation tests the hypothesis that healthy workers are more productive per unit of labor input. Thus improvement in health can increase the effective units of labor while the labor hour inputs remain unchanged. Acemoglu and Johnson (2006) show (using the innovative instrument for life expectancy of predicted mortality based on cause of death data) that between 1940 and 1980 improvements in life expectancy did not contribute to the increase in GDP per capita growth across this same period.

The analysis of the effects of health improvements on economic growth has been well explored since Kelley (1988) found result that population had not effect on economic growth. This led to a flurry of research looking at demographic variables and their effect on economic growth (for example Bloom et al., 2004; Webber, 2002) . The results have been mixed. But all studies focus on the single line equation of the direct effect of health on economic growth.

In this paper I draw on economic theory and the concept that health can also influence economic growth through its incentive effect on education investment. Individuals who are healthier live longer, and are encouraged to invest more in education as the time horizon over which returns to education can be enjoyed in the form of higher skilled wages is extended. In this case, the change in human capital stock (education) will be affected by the *health* stock. This concept is well explored in the theoretical literature, but there are few cross country empirical studies testing this hypothesis. In this paper I show that empirical specifications that ignore the indirect effect of health on economic growth underestimate the positive impact health has on economic growth.

The aim of this paper is to delineate the causal influence of health on economic growth. The hypothesis that health has both a direct and indirect effect on economic growth is tested using a system of equations. The system is composed of three equations: economic growth, education, and fertility. Health enters the economic growth equation directly, and indirectly through the education and fertility equations. In developing these three simultaneous equations I draw on past empirical work: economic growth from Sala-i-Martin et al. (2004); education from Zhang and Zhang (2005); and fertility from Schultz (1997). Thus the individual equations are not unique to this study, but their combination is.

2 Literature Review

Analysis of the effect of health on economic development is broken into empirical and theoretical studies. The empirical literature (Bloom et al., 2004; Webber, 2002; Knowles and Owen, 1997; Acemoglu and Johnson, 2006) focus on the labor productivity effects of health on economic growth where improvements in health lead to an increase in per capita income directly as each individual is able to produce more per unit of labor input. The theoretical models, however, explore the relationship between health and economic growth via an indirect incentive effect on education investment (Blackburn and Cipriani, 2002; Chakraborty, 2004; Ehrlich and Lui, 1991; Finlay, 2005; Kalemli-Ozcan et al., 2000; Zhang et al., 2001). Lorentzen et al. (2005) are the first to attempt to bridge the gap of the theoretical and empirical work in a cross country empirical study. Their use of the Barro and Lee (1984) data set for education weakens the result for in that data set the time series for each country do not provide realistic changes in the years of schooling (see for example the series for the USA). Moreover, Lorentzen et al. (2005) do not include health in the main equation, and the potential direct effects of health cannot be identified. The use of adult mortality rates in Lorentzen et al. (2005) is a valuable application over the use of life expectancy as a proxy for health as the effects of child mortality can be separated from the effects of adult mortality. The specifications in Lorentzen et al. (2005) are created by the authors, and although each of the equations in the system is justifiable they are not consistent with, nor as informative as, those in the existing literature.

The aim of this paper is to simultaneously estimate equations for economic growth, education and fertility, which have individually been recognized in their respective literature streams, to identify both the direct and indirect effects of health on economic growth.

Regression coefficients explaining cross country differences in economic growth are abundant (Easterly, 2002). To stall the mining for potentially important explanatory variables, Sala-i-Martin et al. (2004) use a Bayesian Average approach to identify the key explanators of cross country differences in economic growth. The specification used in this study is drawn from the top ranking explanatory variables identified by Sala-i-Martin et al. (2004). Initial income, education, and investment price, along with dummies for population coastal density, East Asian and African countries, tropical area, malaria prevalence, and fraction Confucian are all included. Of particular interest to this paper are the demography variables, and life expectancy, mortality, and fertility are also included in the economic growth regressions. These variables feature in the Sala-i-Martin et al. (2004) list of explanatory variables, but are not the top ranking as the former list is. As catalogued by Bloom et al. (2004), however, the significance of the demographic variables in growth regressions has been asserted by many other authors.

The fertility equation is drawn from Schultz (1997). He considers the determinants of fertility to be education, income, sector of employment, religion, nutrition, family planning and child mortality. Using data on country specific abortion laws and government views of fertility, the specification and results of the fertility equation are consistent with that of Schultz (1997) with child mortality positive and significant and family planning laws also having a significant effect.

Specifications detailing cross country differences in education are scant. Acemoglu and Pischke (2000) outline a simple specification for college education based on income and region fixed effects. However, a specification consistent with the theory regarding the incentive effect of health on education is that of Zhang and Zhang (2005). Their paper outlines a system of equation where in its simplest form education, investment, fertility and income are endogenous and jointly determined, and life expectancy also features as an explanatory variable in each of the system's regressions. In this paper I follow this simple specification where average years of schooling is explained by base year education, income and adult mortality rates (in robustness checks I add other explanatory variables). The inclusion of adult mortality enables the identification of the effect health has on education. Following the theoretical literature, an increase in health which lowers adult mortality will increase investment in education as the time horizon over which the returns to education can be awarded is extended. Thus the key indirect link, referring back to the economic growth regression is the effect of mortality on education, and then education on economic growth.

Bloom et al. (2004) provide a summary of results of various studies that use life expectancy as a proxy for health in the analysis of the direct effect of health on economic growth. Across the studies they cite (Barro and Lee, 1984; Bhargava et al., 2001; Barro and i Martin, 2004; Sachs and Warner, 1997) life expectancy is shown to have a positive and significant effect on economic growth. Barro and Lee (1984) show that life expectancy has a significant positive effect on economic growth, but voice an old concern that life expectancy is a proxy for worker experience and the extension of a life time represents higher workforce participation rather than representing improvements in health. To isolate the role of health from experience Bloom et al. (2004) control for workforce experience and show that life expectancy as a proxy for health has a significant positive effect on economic growth. Their results indicate that there is a real productivity effect of health on economic growth.

In this paper I present the analysis of not just the direct labor productivity effect of health, but also the indirect incentive effect. Using the overlapping generations model many authors (Blackburn and Cipriani, 2002; Chakraborty, 2004; Ehrlich and Lui, 1991; Finlay, 2005; Kalemli-Ozcan et al., 2000; Zhang et al., 2001) show that an increase in life expectancy will increase investment in education. Human capital accumulation (that is, education) is assumed to be the driver of economic growth, and an increase in life expectancy will expand the time horizon over which returns to education can be earned and thus encourage investment as the present value of lifetime earnings increases.

To date, the indirect effect of health on economic growth has been little explored in the empirical literature. Lorentzen et al. (2005) are the first to adopt the system of equations approach but exclude health from the growth regression and only include it in the equation for education. Thus they do not simultaneously identify the direct and indirect effects of health. To clarify the concept of an indirect effect from an interactive term, the interactive term of health*education in an economic growth regression has a different interpretation than a system of equations. A significant interactive term shows that exogenous improvements in education heighten the benefits of an increase in health on economic growth. Whereas, in the system of equations health improvements actually act to increase education and this then lead to an increase in economic growth.

3 Data

The data used in this project is collated from many different sources. The gross domestic product series, for growth and initial income, are taken from Penn World Tables mark 6.2 (Heston et al., 2002). The data for the average years of schooling comes from Cohen and Soto (2006). I choose to use this data over the Barro and Lee (1984) average years of schooling data as some of the series, for example that for the USA, have unexplainable spikes.

Data detailing the fertility rate, adult and child mortality, and life expectancy all come from the World Development Indicators (World Bank, 2003), as are the series for employment in agriculture and the urbanization rate. Cross sectional control variables, East Asian dummy, initial investment price, fraction of the country in a tropical area, population coastal density, fractions Confucian, catholic, protestant, and Muslim, colony dummy, come from the Sala-i-Martin et al. (2004) data set which is available on Doppelhoffer's web site

The indicator variables for abortion laws was constructed from the United Nations Population Policy Data Bank Data on contraceptive prevalence, government view on fertility and government fertility intervention programs were taken from the World Population Trends and Policies published by the United Nations (see United Nations, 2005). A more detailed description of the data and the sources are provided in the appendix.

4 Model

The indirect effect of health on economic growth can be represented in a two period utility maximization problem. While the direct effect enters the production function as a labor augmenting factor along with schooling.

Consider an adaptation of the model presented in Finlay (2005), where health has an indirect effect on economic growth through its promotion of education investment. (Note that the indirect effect is isolated from the direct labor productivity effect).

The individual maximizes their utility over first and second period consumption, and survival through to the second period is uncertain and depends on the level of investment in health made in the first period, h_t, and some exogenous factor, z. I assume an interior solution.

$$U_t = u\left[c_t\right] + \pi_t(h_t, z)u\left[c_{t+1}\right] \tag{1}$$

In Finlay (2005) a constant relative risk aversion is assumed and the felicity takes the form of

$$u\left[c\right] = \frac{c^{1-\gamma}}{1-\gamma} \tag{2}$$

Assumptions over the nature of the probability of survival function are made, and, importantly, $\pi_t^{'}(h_t, z) > 0$, and $\pi_t^{''}(h_t, z) < 0$. Human capital is assumed to be the driver of economic growth, and it accumulates according to time invested in schooling, s_t, compulsory schooling, $\bar{s}$, inherited human capita, $\bar{e}$, and the productivity of human capital production, B. A person born in period t will have a stock of human capital in $t+1$ that equates to,

$$e_{t+1}^{t} = B(\bar{s} + s_t)e_t^{t-1} + B\bar{e}(\bar{s} + s_t) \tag{3}$$

The production function of an individual shows the mechanism of labor augmenting human capital,

$$y_{t+i} = Ae_{t+i}^{t}l_{t+i}^{t}, i = 0, 1 \tag{4}$$

Output is increasing in effective labor,

$$\frac{\partial y_{t+i}}{\partial e_{t+i}} > 0 \tag{5}$$

That is, output is increasing in education.

An individual is constrained by both time and income. All of the schooling is done in the first period of life, and thus the labor supply hours, l_t, are shortened in that period but not in the second. Normalizing time in each period to one, and assuming an interior solution,

$$l_t = 1 - \bar{s} - s_t \tag{6}$$

The health expenditure comes in the first period, so total income is split between consumption and health improving technologies.

$$c_t = y_t - h_t \tag{7}$$

$$c_{t+1} = y_{t+1} \tag{8}$$

The maximization problem is then reduced to,

$$\max_{s,h} U_t = \frac{\left(Ae_t^t(1-\bar{s}-s_t)-h_t\right)^{1-\gamma}}{1-\gamma} + \pi_t(h_t, z)\frac{\left(ABe_t^t(\bar{s}+s_t)\right)^{1-\gamma}}{1-\gamma} \tag{9}$$

$$s.t. s_t > 0, h_t > 0 \tag{10}$$

The first order conditions are,

$$\frac{\partial U}{\partial s} = \frac{-Ae_t}{(Ae_t(1-s_t-\bar{s})-h_t)^{\gamma}} + \pi(h_t, z)\frac{ABe_t}{(ABe_t(s_t+\bar{s}))^{\gamma}} = 0 \tag{11}$$

$$\frac{\partial U}{\partial h} = \frac{-1}{(Ae_t(1-\bar{s}-s_t)-h_t)^{\gamma}} + \pi'(h_t, z)\frac{ABe_t(\bar{s}+s_t)^{1-\gamma}}{1-\gamma} = 0 \tag{12}$$

Combining these two first order conditions we get the Euler equation that details the optimal payoff between health and schooling investment,

$$\frac{1-\gamma}{Ae_t(s_t+\bar{s})} = \frac{\pi'(h_t,z)}{\pi(h_t,z)} \tag{13}$$

Totally differentiating this expression to find the relationship between health and schooling, we see that,

$$\frac{-(1-\gamma)Ae_t}{(Ae_t(\bar{s}+s_t))^2}ds = \frac{\pi''(h_t,z)\pi'(h_t,z) - \pi'(h_t,z)^2}{\pi(h_t,z)^2}dh \tag{14}$$

Given the assumptions over the properties of the survival function, the signs of the left and right hand sides are the same. Thus changes in schooling and changes in health move in the same direction.

$$\frac{ds}{dh} > 0 \tag{15}$$

To capture this indirect effect in an econometric framework, I adopt a system of equations. Each of the individual specified regressions are drawn from existing literature. The unique contribution of this paper is that the equations are combined, and jointly determined. The choice of models is discussed in detail in the literature review section above, here I outline the three equations.

The growth regression is an adaptation of (Sala-i-Martin et al., 2004),

$$\begin{aligned}(\log(GDP_{it}) - \log(GDP_{i0}))/T &= \beta_0 + \beta_1 \log(GDP_{i0}) \\ &+\beta_2 \log(Total\_years\_of\_schooling_{it}) \\ &+\beta_3 Fertility_{it} + \beta_4 \log(Adult\_male\_mortality)_{it} \\ &+X_{it}'\delta + \epsilon_{it}\end{aligned} \tag{16}$$

where X=X(East Asian dummy, investment price, fraction tropical, log population coastal density, fraction confucian).

The education equation is taken from Zhang and Zhang (2005)

$$\log(Total\_years\_of\_schooling_{it}) = \gamma_0 + \gamma_1 \log(GDP_{i0}) + \gamma_2 \log(Adult\_male\_mortality)_{it} + Z_i^{'}\theta + \upsilon_{it} \quad (17)$$

where Z=Z(fraction confucian, colony dummy).

The fertility equation is taken from Schultz (1997)

$$Fertility_{it} = \alpha_0 + \alpha_1 \log(GDP_{i0}) + \alpha_2 \log(Total\_years\_of\_schooling_{it}) + \alpha_3 Child\_Mortality_{it} + P_i^{'}\zeta + \mu_{it} \quad (18)$$

Where P=P(employment in agriculture, urbanization, fraction Catholic, fraction Protestant, fraction Muslim, contraceptive access, government view on fertility, government fertility intervention, abortion if pregnancy is life threatening to mother, abortion if pregnancy caused by rape).

Initial values, that is,1960 values, of total years of schooling, fertility and adult male mortality are used as instruments for the 1960-2000 averages in the two stage least squares regressions.

When estimating the three equations simultaneously, the errors are assumed to be correlated. Country and time specific shocks affect economic growth, education and fertility in a correlated fashion.

5 Results

The key result presented below is that health has a positive and significant effect on economic growth.

The descriptive statistics in Figure 1 summarize the key variables used in this paper. The average annual growth rate across the period 1960 to 2000 across the sample of countries is 2.13 percent, while China and Korea have the highest annual average growth rate above 5 percent. The average years of schooling is 6.35, with a maximum of 11.71 years, which is consistent with the level in many of the OECD countries. The average fertility rate, 3.73 per woman is higher than that in most OECD countries in 2000. This is because the sample includes poor countries with higher fertility rates, and moreover the fertility rate in many rich countries has declined significantly since 1960. Thus the 1960-2000 average fertility rate remains higher than current fertility rates in rich countries. Note that the average mortality rates are taken from 1960-1997, as only 17 countries have data available for this series after this date. Cameroon, South Africa, Tanzania, Uganda, and Zambia have the highest adult male mortality across the sample period, and Cameroon, Ethiopia, Madagascar, Tanzania, Uganda, and Zambia have the lowest life expectancy. The discrepancy between the two groups of countries driven by the relatively high child mortality in Ethiopia and Madagascar.

The government view on fertility takes on three possible values, -1 if the government wants to lower fertility, 0 to maintain, and 1 to raise fertility. The average attitude across the 40 year sample period is taken. Averaging the abortion laws, which enter as 0-1 dummies is also done across the 40 year period. With an average of 0.95, this indicates that most countries had abortion available over this period when pregnancy was caused by rape.

The regressions are conducted as follows. With the end goal of estimating a system of equations to jointly determining economic growth, education and fertility, the indirect effect of health on education is estimated jointly along with its direct effect on economic growth. The first three tables of regressions are the estimations of the equations as single line equations, the fourth table of regressions is the system of equation, and the tables that follow are robustness checks where different measures for health and schooling, the key variables of interest, are used to verify the results presented in the first four tables. To clarify, the regressions are essentially cross sectional. Each country is assigned observations that are the average value across the 40 year time period. Although the variation across time within a country is not exploited, the use of the initial year values as instruments for the 40 year averages

The regressions for economic growth detailed in Figure 2 indicate that education has a positive and significant effect in explaining cross country differences in economic growth. The magnitude of the instrumented schooling coefficient in the two stage least squares

(2SLS) estimation are higher than the OLS coefficients. Instrumental variables can be used to overcome attenuation bias (where the OLS coefficient is too small due to the presence of measurement error), or simultaneity bias (OLS coefficients are too large). In the case where the 2SLS coefficient is large than the OLS coefficient, this suggests that the instrument has assisted in reducing the attenuation bias. The fertility rate loses its significance when estimating using 2SLS and controlling for the various country specific dummies (religion, geography, etc). Comparing the first two columns of Figure 2 the absolute value of the coefficient declines when using 2SLS to estimate the regression. Unlike the schooling variable, this indicates that the simultaneity bias has been controlled for in part with the use of the instrumental variable. The income convergence term is negative and significant as expected. Unlike many of the models that use life expectancy as a proxy for health, the adult male mortality variable is not significant in any of the specifications. In the robustness checks in Figure 6, the life expectancy yields a positive and significant coefficient. This result is consistent with Bloom et al. (2004) and others. I also run the same regression with both male adult mortality and child mortality, but neither are individually significant (nor jointly significant at the 5 per cent level) indicating the discrepancy between life expectancy and adult male mortality results is not driven by child mortality. Given the difference in the significance of adult male mortality and life expectancy, when estimating the system of equations I use life expectancy in the system as a proxy for health to verify the results I get with adult male mortality.

In the regressions for total years of schooling, I use a simple model as set out by Zhang and Zhang (2005), and find that initial levels of schooling are a significant positive explanator of subsequent years total years of schooling. In the OLS results, the contemporaneous mortality rate is a significant and negative correlate of average years of schooling. But once this contemporaneous variable is instrumented for, the effect of adult male mortality on education is no longer significant. In the robustness checks shown in Figure 7 the same insignificance of health is observed when using life expectancy and average years of secondary schooling. This is an important point, as we will see that the effect of adult male mortality on education becomes significant in the system of equation.

The fertility regression is taken from Schultz (1997), and the key result here is that child mortality has a significant positive effect on fertility. Whether this is justified by hoarding or replacement, the results confirm that higher child mortality leads to higher fertility. Government fertility intervention programs also result in lower fertility – governments that aim to raise fertility (the dummy is 1) observe lower fertility hence the reason for the intervention.

The system of equations is outlined in Figure 5. First, looking at the adult male mortality explanatory variable (the average is instrumented with the base year value) the indirect effect of adult male mortality is positive and significant: a decrease in adult male mortality will raise the total years of schooling, and higher total years of schooling will raise GDP growth. The direct effect of adult male mortality, however, is insignificant. The insignificance of the direct effect is consistent with the Acemoglu and Johnson (2006) prediction that health does not explain cross country differences in economic growth. However, once we take into account the indirect incentive effects of health on education, and education driving growth, we see that health does explain the cross country variation in economic growth. This is an important finding, as a single line equation detailing health on growth does not capture the full dynamic of the role of health in economic development and its indirect effect must be captured to show the influence of health on economic growth.

The overall effect of mortality reduction on economic growth can be traced by economic significance and by statistical significance. There are three avenues in the above system of equations that capture the effect of a decline in mortality on economic growth. The indirect and direct effects of adult male mortality account for two of these effects, and the third comes from the relationship between child mortality and fertility and then fertility on economic growth.

Consider the steady state level of per capita income where economic growth is zero

$$\log(GDP_t) - \log(GDP_0) = 0 \tag{19}$$

then isolating the marginal effect of education economic growth from the regression in 16, we get,

$$\begin{aligned} \frac{\partial GDP_t}{\partial Total\_years\_of\_schooling_t} &= \frac{-\beta_2}{\beta_1} \frac{GDP_t}{Total\_years\_of\_schooling_t} && (20) \\ &= \frac{-(0.0093871)}{-0.0116923} \frac{12038.48}{7.861129} && (21) \\ &= 1229.5 && (22) \end{aligned}$$

Such that, increasing the average total years of schooling by one year, will raise steady state GDP per capita by $1229.50, holding everything else constant in equilibrium. The marginal effect of a decrease in mortality on economic growth through education can be calculated. A one standard deviation (114.83 men per 1000) decline in mortality, a 45% decrease from 255.18 men/1000 to 140.35 men per 1000, will lead to a 4.99% increase in the average total years of schooling. From the mean years of schooling, this implies that average total years of schooling increases from 7.86 to 8.25 years of schooling. The 0.39 increase in the average total years of schooling implies a 479.51 increase in per capita income at the mean level of GDP per capita. This difference in the adult male mortality rate of 114 per 1000 from a mean of 255 per 1000 is like comparing Egypt 1960-2000 average morality rate to that of Norway.

Consider all of the channels by which health can influence economic growth in steady state, by first examining the magnitudes of the coefficients rather than their significance, then we see a large effect of health in explaining cross country differences in economic growth. Figure 10 details the full effect of health improvements on economic development. Taking into account the indirect effects from child mortality on fertility, adult mortality on education, and the direct effect of mortality, the total effect of health improvements are calculated. The improvement in health for each country is a country specific one standard deviation improvement.

Another system of equations is estimated using life expectancy instead of adult male mortality, and results are presented in Figure 9. In this case I find that life expectancy has both an indirect and a direct effect on economic growth. Again, these results show that simply using the single line equation of health on growth underestimates the role of health in economic development.

6 Discussion

Recent work by Acemoglu and Johnson (2006) suggests that although health improvements are a valuable goal within itself, they do not have a significant effect on economic growth. The results in this paper show otherwise – once the indirect effect of health on economic growth is taken into account we see that health does have a positive and significant effect on economic growth. Using a single line equation to represent health, and thus only capture the labor productivity effect of growth, leads to an underestimation of the role of health in economic development. Theoretical literature suggests that increasing life span will affect an individual's decisions over investment in education. Education is costly in terms of time out of the workforce, but has the return of higher wages. With a positive discount rate, these wages must be higher and/or must be earned over a period of time greater than the time spent in education. Thus if the time horizon over which the higher skilled wage can be earned is longer, then the marginal benefit of education increases. This indirect effect is observed in the data. The positive and significant effect of education on economic growth indicates that this channel from health to growth is complete.

7 Conclusion

This paper elucidates an important point: health does play a role in economic development. Before dismissing its role in determining cross country differences in economic growth the channels by which health influences economic growth must be considered. In this paper I have shown that health influences economic growth via education incentive effects, and more weakly through a fertility effect.

8 Appendix

8.1 List of countries in sample

Algeria, Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Denmark, Dominican Republic, Ecuador, Egypt,A rab Rep., El Salvador, Ethiopia, Finland, France, Ghana, Greece, Guatemala, Honduras, India, Indonesia, Iran, Islamic Rep., Ireland, Italy, Jamaica, Japan, Kenya, Korea, Rep., Madagascar, Malaysia, Mexico, Morocco, Nepal, Netherlands, New Zealand, Nicaragua, Norway, Panama, Paraguay, Peru, Philippines, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Tanzania, Thailand, Trinidad and Tobago, Uganda, United Kingdom, United States, Uruguay, Venezuela, RB, Zambia.

8.2 Data Descriptions

Growth GDP per capita 1960-2000: Penn World Tables mark 6.2, Real GDP per capita, Constant Prices: Laspeyres, PPP (which PWT call International $) in 2000 Constant Prices.

Log total years of schooling, >15yr olds, http://www.iae-csic.uab.es/soto/Data.htm and see the link to "Growth and human capital: Good data, good results", (with Daniel Cohen), Education Database (external source). The series are constructed from the OECD database on educational attainment and from surveys published by UNESCO.

Fertility Rate: World Bank (2003). Fertility rate, total (births per woman), total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with prevailing age-specific fertility rates. For more information, see Tables: WDI 2.2 and 2.15.

Adult Male Mortality: World Bank (2003). Mortality rate, adult, male (per 1,000 male adults), adult mortality rate (male) is the probability of dying between the ages of 15 and 60 – that is, the population of 15-year olds who will die before their 60th birthday. For more information, see Tables: WDI 2.17.

East Asian dummy: as defined by Sala-i-Martin et al. (2004), and in this data set includes China, Indonesia, Japan, Korea, Rep., Malaysia, Philippines, Singapore, Thailand. Data are available at http://www.econ.cam.ac.uk/faculty/doppelhofer/research/bace.htm#data

Investment Price: as defined by Sala-i-Martin et al. (2004) as the "average investment price level between 1960 and 1964 of purchasing power parity basis." From (Heston et al., 2002).

Fraction Tropical: as defined by Sala-i-Martin et al. (2004) as the "proportion of the country's land area within geographical tropics." From Gallop et al. (2001).

Population Coastal Density: as defined by Sala-i-Martin et al. (2004) as "coastal (within 100km of coastline) population per coastal area in 1965." From Gallop et al. (2001).

Fraction Confucian: as defined by Sala-i-Martin et al. (2004) as the "fraction of the population confucian." From Barro (1999).

Colony Dummy: as defined by Sala-i-Martin et al. (2004) as the "dummy for former colony." From Barro (1999).

Child Mortality: World Bank (2003). Mortality rate, under-5 (per 1,000 live births), under-5 mortality rate is the probability of a child born in the indicated year dying before reaching the age of 5, if subject to current age-specific mortality rates. The probability is expressed as a rate per 1,000. For more information, see Tables: WDI 2.17.

Employment in Agriculture, 1960: World Bank (2003). As a percentage of total employment.

Urbanization: World Bank (2003).. As a percentage of total population.

Fraction Catholic: as defined by Sala-i-Martin et al. (2004) as the "fraction of the population Catholic." From Barro (1999).

Fraction Protestant: as defined by Sala-i-Martin et al. (2004) as the "fraction of the population Protestant." From Barro (1999).

Fraction Muslim: as defined by Sala-i-Martin et al. (2004) as the "fraction of the population Muslim." From Barro (1999).

Malaria Prevalence in the 1960s: as defined by Sala-i-Martin et al. (2004) as the "index of Malaria prevalence in 1966." From Gallop et al. (2001).

Africa dummy: as defined by Sala-i-Martin et al. (2004) as the " dummy for Sub-Saharan African countries." In the sample for this paper it includes: Cameroon, Ethiopia, Ghana, Kenya, Madagascar, South Africa, Tanzania, Uganda, Zambia.

Government View on Fertility: An index is created for the years in which data are available 1970-2000, where the "governments' perception of the acceptability of current fertility and of the desirability of intervention to change it" is indexed as 1 if the "rates are not satisfactory; too low; higher rates desirable"; 0 if the "rates satisfactory"; -1 if the "rates not satisfactory; too high; lower rates desirable." The exact wording of the classification is taken from Tables 51-56 of the United Nations World Population Trends and Policies 1979 Monitoring Report Volume II Population Policies. An average is then taken over the period 1960-2000, thus the index ranges between -1 and 1 as a continuous variable. Also see United Nations (2005).

Governments' Fertility Intervention Program: An index is created for the years in which data are available 1970-2000, where the "governments desirability of intervention to change" fertility rates is assigned -1 if the government intervenes in an attempt to lower the fertility rate, 0 if the government intervenes to maintain the fertility rate or does not intervene, and 1 if the government intervenes to raise the fertility rate. The exact wording of the classification is taken from Tables 51-56 of the United Nations World Population Trends and Policies 1979 Monitoring Report Volume II Population Policies. An average is then taken over the period 1960-2000, thus the index ranges between -1 and 1 as a continuous variable. Also see United Nations (2005).

Contraceptive Access: An index is created for the years in which data are available 1970-2000, where "policies relating to effective use of modern methods of fertility regulation" are categorized as 0 if governments limit access, 1 if access is not limited but no support is provided, 2 if access is not limited and indirect support is provided, and 3 if access is not limited and direct support is provided. The exact wording of the classification is taken from Tables 57, 58, 59, 60 of the United Nations World Population Trends and Policies 1979 Monitoring Report Volume II Population Policies. An average is then taken over the period 1960-2000, thus the index ranges between 0 and 3 as a continuous variable. Also see United Nations (2005).

Abortion available if pregnancy is life threatening to mother: This is an indicator variable that takes the value of 1 if an abortion is available in the situation where a pregnancy is life threatening to the mother, and a 0 otherwise. It is taken from the Population Policy Data Bank which is maintained by the Population Division of the Department of Economics and Social Affairs of the United Nations Secretariat.

Abortion available if pregnancy is caused by rape: This is an indicator variable that takes the value of 1 if an abortion is available in the situation where a pregnancy was caused by rape, and a 0 otherwise. It is taken from the Population Policy Data Bank which is maintained by the Population Division of the Department of Economics and Social Affairs of the United Nations Secretariat.

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Variable	Obs	Mean	Std. Dev.	Min	Max
Growth per capita av annual 1960-2000	62	2.13	1.38	-1.07	5.80
GDP per capita 1960	62	4641.85	3728.96	372.11	15254.23
GDP per capita av.1960-2000	62	7729.02	6151.38	491.30	21606.13
Investment Price, av. 1960-2000	62	83.59	41.35	26.54	287.27
Years of Schooling, 1960	62	4.46	2.83	0.12	10.54
Total years of schooling, av. 1960-2000	62	6.35	2.88	0.88	11.77
Fertility, av. 1960-2000	62	3.73	1.53	1.74	7.09
Adult male mortality, av. 1960-2000	62	255.18	114.83	125.05	571.16
Life Expectancy, av. 1960-2000	62	65.64	9.38	41.91	76.44
Child mortality, av. 1960-2000	62	74.97	60.14	9.84	216.24
East Asian Dummy	62	0.13	0.34	0	1
Population Coastal Density, 1965	62	125.73	392.80	0	3081.97
Area in tropics	62	0.49	0.48	0	1
Malaria prevalence, 1966	62	0.20	0.35	0	1
Fraction confucian	62	0.02	0.09	0	0.60
Sub-Saharan Africa dummy	62	0.15	0.36	0	1.00
Former Colony dummy	62	0.66	0.48	0	1
Employment in Agriculture, 1960 (% of total)	62	25.30	24.74	0.51	85.45
Urbanization rate av. 1960-2000	62	53.35	22.27	7.62	100
Proportion Catholic	62	0.45	0.44	0	1
Proportion Protestant	62	0.18	0.33	0	0.99
Proportion Muslim	62	0.09	0.23	0	0.98
Contraceptive access	62	2.73	0.43	1.43	3
Govt view on fertility	62	-0.31	0.58	-1	1
Govt fertility intervention	62	-0.33	0.54	-1	0.86
Abortion if life threatening to mother	62	0.95	0.18	0	1
Abortion if caused by rape	62	0.40	0.42	0	1

Figure 1: Descriptive Statistics

Dependent Variable: Average Annual Growth of GDP per capita 1960-2000				
	(1)	(2)	(3)	(4)
Real GDP per capital 1960 (log)	-1.726***	-1.580***	-1.222***	-1.163***
	(0.170)	(0.164)	(0.226)	(0.229)
Investment price, (log)	0.070	0.082	0.059	-0.022
	(0.248)	(0.262)	(0.239)	(0.221)
Total years of schooling, av. 1960-2000 (log)	0.451*	0.940***	0.318	0.816**
	(0.255)	(0.296)	(0.266)	(0.403)
Fertility rate, av.1960-2000	-1.010***	-0.734***	-0.693***	-0.193
	(0.125)	(0.137)	(0.138)	(0.260)
Adult male mortality, av.1960-2000 (log)	-0.770	-0.636	-0.553	-1.045
	(0.490)	(0.494)	(0.537)	(0.638)
East Asian dummy			0.715	0.868*
			(0.468)	(0.498)
Population coastal density, (log)			0.108**	0.197***
			(0.051)	(0.064)
Fraction of tropical area			-0.413	-0.902**
			(0.292)	(0.384)
Malaria prevalence in 1960s			0.469	0.478
			(0.567)	(0.577)
Fraction Confucian			1.367	1.104
			(0.948)	(1.002)
African dummy			-0.507	-0.564
			(0.583)	(0.671)
Constant	22.937***	19.140***	16.461***	16.214***
	(3.389)	(3.271)	(3.688)	(4.132)
Observations	62	62	62	62
R-squared	0.77		0.82	
Estimation Technique	OLS	2SLS	OLS	2SLS
Anderson canon. Corr. LR statistic p-value		0.00		0.00
Hansen J p-value		exactly id.		exactly id.
Robust standard errors in parentheses				
* significant at 10%; ** significant at 5%; *** significant at 1%				

Figure 2: Economic Growth Regressions

Dependent Variable: Total years of schooling, av. 1960-2000 (log)				
	(1)	(2)	(3)	(4)
Real GDP per capital 1960 (log), PWT6.2	0.015	0.043	0.038	0.062
	(0.028)	(0.036)	(0.033)	(0.039)
Total years of schooling, 1960 (log)	0.613***	0.622***	0.599***	0.607***
	(0.028)	(0.029)	(0.030)	(0.029)
Adult male mortality, av.1960-2000 (log)	-0.126***	-0.020	-0.106**	-0.011
	(0.044)	(0.064)	(0.051)	(0.075)
Fraction Confucian			0.345**	0.370***
			(0.141)	(0.120)
Colony dummy			0.001	-0.019
			(0.022)	(0.022)
Constant	1.500***	0.690	1.214***	0.512
	(0.309)	(0.532)	(0.388)	(0.603)
Observations	62	62	62	62
R-squared	0.97		0.97	
Estimation Technique	OLS	2SLS	OLS	2SLS
Anderson canon. Corr. LR statistic p-value		0.00		0.00
Hansen J p-value		exactly id.		exactly id.
Robust standard errors in parentheses				
* significant at 10%; ** significant at 5%; *** significant at 1%				

Figure 3: Total Years of Schooling Regressions

Dependent Variable: Fertility Rate av. 1960-2000				
	(1)	(2)	(3)	(4)
Real GDP per capita, 1960 (log)	-0.226	-0.302	-0.121	-0.159
	(0.224)	(0.226)	(0.211)	(0.211)
Total years of schooling, av. 1960-2000 (log)	0.094	0.203	0.150	0.136
	(0.468)	(0.452)	(0.375)	(0.350)
Years of secondary schooling, av.1960-2000 (log)				
Urbanization, av.1960-2000	-0.009	-0.012	-0.004	-0.008
	(0.008)	(0.009)	(0.007)	(0.007)
Child mortality, av.1960-2000	0.022***	0.019***	0.018***	0.015***
	(0.004)	(0.004)	(0.003)	(0.003)
Employment in agriculture 1960	-0.006	-0.002	-0.008	-0.006
	(0.011)	(0.011)	(0.008)	(0.008)
Fraction Catholic	0.395	0.547	-0.017	0.031
	(0.375)	(0.387)	(0.307)	(0.312)
Fraction Protestants	0.230	0.290	-0.465	-0.496
	(0.426)	(0.410)	(0.356)	(0.353)
Fraction Muslim	-0.075	0.223	-0.564	-0.399
	(0.594)	(0.590)	(0.540)	(0.513)
Contraceptive access			0.171	0.145
			(0.172)	(0.176)
Govt view on fertility			-1.202*	-1.392**
			(0.643)	(0.603)
Govt fertility intervention program			0.803	0.959*
			(0.623)	(0.555)
Abortion available if pregnancy is life threatening to mother			0.852*	0.841*
			(0.469)	(0.442)
Abortion available if pregnancy is caused by rape			-0.675***	-0.672***
			(0.193)	(0.177)
Constant	4.224**	4.798**	2.493	3.279*
	(2.017)	(2.108)	(1.950)	(1.944)
Observations	62	61	62	61
R-squared	0.84		0.90	
Estimation Technique	OLS	2SLS	OLS	2SLS
Anderson canon. Corr. LR statistic p-value		0.00		0.00
Hansen J p-value		exactly id.		exactly id.
Robust standard errors in parentheses				
* significant at 10%; ** significant at 5%; *** significant at 1%				

Figure 4: Fertility Rate Regressions

	(1)	(2)	(3)
	Growth	Education	Fertility
Real GDP per capita 1960 (log)	-1.129***	0.037	-0.058
	(0.213)	(0.027)	(0.203)
Total years of schooling, av.1960-2000 (log)	0.512*		0.679**
	(0.303)		(0.337)
Total years of schooling, 1960 (log)		0.594***	
		(0.024)	
Fertility rate, av.1960-2000	-0.355*		
	(0.213)		
Adult male mortality, av.1960-2000 (log)	-0.934	-0.132**	
	(0.629)	(0.059)	
East Asian dummy	0.751**		
	(0.342)		
Investment price, (log)	-0.005		
	(0.236)		
Population coastal density, (log)	0.177***		
	(0.067)		
Fraction of tropical area	-0.743**		
	(0.311)		
Malaria prevalence in 1960s	0.453		
	(0.483)		
African dummy	-0.509		
	(0.550)		
Fraction Confucian	1.467	0.379**	
	(1.182)	(0.162)	
Colony dummy		0.034	
		(0.038)	
Child mortality, av.1960-2000			0.026***
			(0.004)
Employment in agriculture 1960			-0.008
			(0.007)
Urbanization, av.1960-2000			-0.004
			(0.007)
Fraction Catholic			0.032
			(0.279)
Fraction Protestants			-0.326
			(0.396)
Fraction Muslim			-0.383
			(0.409)
Contraceptive access			0.285
			(0.208)
Govt view on fertility			-0.614
			(0.532)
Govt Fertility intervention program			0.359
			(0.499)
Abortion available if pregnancy is life threatening to mother			0.788**
			(0.384)
Abortion available if pregnancy is caused by rape			-0.713***
			(0.198)
Constant	16.381***	1.350***	0.289
	(4.080)	(0.457)	(2.113)
Observations	62	62	62
Estimation Technique		3SLS	
Standard errors in parentheses			
* significant at 10%; ** significant at 5%; *** significant at 1%			

Figure 5: System of Equations

Dependent Variable: Average Annual Growth of GDP per capita 1960-2000				
	(1)	(2)	(3)	(4)
Real GDP per capital 1960 (log)	-1.083***	-1.164***	-1.307***	-1.392***
	(0.190)	(0.221)	(0.206)	(0.225)
Investment price, (log)	-0.061	-0.203	-0.099	0.048
	(0.217)	(0.315)	(0.261)	(0.205)
Total years of schooling, av. 1960-2000 (log)		-0.321		0.498
		(0.348)		(0.318)
Years of secondary schooling, av.1960-2000 (log)	0.464***		0.196	
	(0.174)		(0.196)	
Fertility rate, av.1960-2000	-0.307	-0.268	-0.224	-0.235
	(0.200)	(0.236)	(0.234)	(0.259)
Adult male mortality, av.1960-2000 (log)	-1.046*			-0.628
	(0.613)			(0.605)
Life expectancy, (log) av.1960-2000		8.198***	6.777***	
		(2.782)	(2.276)	
Child mortality, (log) av.1960-2000				-0.512
				(0.340)
East Asian dummy	0.842*	0.979**	0.832*	0.424
	(0.468)	(0.413)	(0.427)	(0.378)
Population coastal density, (log)	0.168***	0.108**	0.129***	0.155***
	(0.053)	(0.054)	(0.049)	(0.053)
Fraction of tropical area	-0.646**	-0.747**	-0.825***	-0.698**
	(0.279)	(0.351)	(0.304)	(0.327)
Malaria prevalence in 1960s	0.507	0.518	0.514	1.189***
	(0.502)	(0.593)	(0.558)	(0.428)
Fraction Confucian	1.599*	1.564*	1.200	1.654**
	(0.839)	(0.804)	(0.806)	(0.759)
African dummy	-0.425	0.461	0.138	-1.706***
	(0.563)	(0.747)	(0.616)	(0.618)
Constant	18.179***	-20.589*	-14.341	18.263***
	(3.810)	(10.834)	(9.165)	(3.963)
Observations	62	62	62	61
R-squared				
Estimation Technique	2SLS	2SLS	2SLS	2SLS
Anderson canon. Corr. LR statistic p-value	0.00	0.00	0.00	0.00
Hansen J p-value	exactly id.	exactly id.	exactly id.	exactly id.
Robust standard errors in parentheses				
* significant at 10%; ** significant at 5%; *** significant at 1%				

Figure 6: Robustness of Economic Growth Regressions

Dependent Variable: Average Years of Schooling av.1960-2000				
	(1)	(2)	(3)	(4)
	Secondary years of schooling	Secondary years of schooling	Secondary years of schooling	Total years of schooling
Real GDP per capital 1960 (log), PWT6.2	0.039	0.051	0.029	0.082*
	(0.076)	(0.096)	(0.093)	(0.045)
Total years of schooling, 1960 (log)				0.618***
				(0.023)
Years of secondary schooling, 1960 (log)	0.582***	0.581***	0.573***	
	(0.042)	(0.043)	(0.048)	
Adult male mortality, av.1960-2000 (log)	-0.107		-0.051	0.026
	(0.137)		(0.217)	(0.101)
Life expectancy, (log) av.1960-2000		0.158		
		(0.498)		
Child mortality, (log) av.1960-2000			-0.044	0.019
			(0.092)	(0.033)
Fraction Confucian	0.479**	0.475*	0.450*	0.398***
	(0.204)	(0.279)	(0.249)	(0.122)
Colony dummy	-0.124**	-0.141**	-0.110*	-0.033
	(0.058)	(0.055)	(0.062)	(0.027)
Constant	0.191	-1.143	0.104	0.076
	(1.205)	(1.589)	(1.512)	(0.712)
Observations	62	62	61	61
R-squared				
Estimation Technique	2SLS	2SLS	2SLS	2SLS
Anderson canon. Corr. LR statistic p-value	0.00	0.00	0.00	0.00
Hansen J p-value	exactly id.	exactly id.	exactly id.	exactly id.
Robust standard errors in parentheses				
* significant at 10%; ** significant at 5%; *** significant at 1%				

Figure 7: Robustness of Education Regressions

Dependent Variable: Fertility Rate av. 1960-2000	
	(1)
Real GDP per capita, 1960 (log)	-0.145
	(0.208)
Years of secondary schooling, av.1960-2000 (log)	0.089
	(0.228)
Urbanization, av.1960-2000	-0.008
	(0.007)
Child mortality, av.1960-2000	0.015***
	(0.003)
Employment in agriculture 1960	-0.006
	(0.008)
Fraction Catholic	0.028
	(0.315)
Fraction Protestants	-0.516
	(0.350)
Fraction Muslim	-0.442
	(0.439)
Contraceptive access	0.150
	(0.179)
Govt view on fertility	-1.426**
	(0.632)
Govt fertility intervention program	0.993*
	(0.582)
Abortion available if pregnancy is life threatening to mother	0.855*
	(0.440)
Abortion available if pregnancy is caused by rape	-0.672***
	(0.181)
Constant	3.562*
	(1.966)
Observations	61
R-squared	
Estimation Technique	2SLS
Anderson canon. Corr. LR statistic p-value	0.00
Hansen J p-value	exactly id.
Robust standard errors in parentheses	
* significant at 10%; ** significant at 5%; *** significant at 1%	

Figure 8: Robustness of Fertility Regressions

	(1)	(2)	(3)
	Growth	Education	Fertility
Real GDP per capita 1960 (log), WDI	-1.224***	0.032	-0.103
	(0.204)	(0.027)	(0.194)
Total years of schooling, av. 1960-2000	-0.301		0.484
	(0.345)		(0.309)
Fertility Rate, WDI av.1960-2000	-0.296		
	(0.199)		
Life Expecancy av. 1960-2000	8.638***	0.420**	
	(2.360)	(0.175)	
East Asian Dummy, SIM	0.850***		
	(0.320)		
Investment Price, SIM (log)	-0.087		
	(0.225)		
Population coastal density, SIM (log)	0.095		
	(0.063)		
Fraction of Tropical Area, SIM	-0.603**		
	(0.288)		
Malaria Prevalence in 1960s, SIM	0.358		
	(0.441)		
African Dummy, SIM	0.661		
	(0.561)		
Fraction Confucian, SIM	1.739	0.313*	
	(1.129)	(0.163)	
Total years of schooling, 1960		0.580***	
		(0.026)	
Colony Dummy, SIM		0.017	
		(0.035)	
Child Mortality av.1960-2000, WDI			0.023***
			(0.003)
Employment in Agriculture 1960, WDI			-0.009
			(0.006)
Urbanization av.1960-2000, WDI			-0.004
			(0.006)
Fraction Catholic, SIM			-0.003
			(0.268)
Fraction Protestants, SIM			-0.389
			(0.380)
Fraction Muslim, SIM			-0.366
			(0.393)
Contraceptive prevalence av.1960-2000, WDI			0.233
			(0.198)
Govt view on Fertility av.1960-2000, WDI			-0.921*
			(0.497)
Govt's Fertility Intervention Program av.1960-2000, WDI			0.604
			(0.474)
Abortion available if pregnancy is life threatening to mother, av.1960-2000			0.791**
			(0.369)
Abortion available if pregnancy is caused by rape, av.1960-2000			-0.663***
			(0.190)
Constant	-22.382**	-1.045*	1.358
	(9.588)	(0.634)	(1.956)
Observations	62	62	62
Estimation Technique		3SLS	
Standard errors in parentheses			
* significant at 10%; ** significant at 5%; *** significant at 1%			

Figure 9: Robustness of the System of Equations

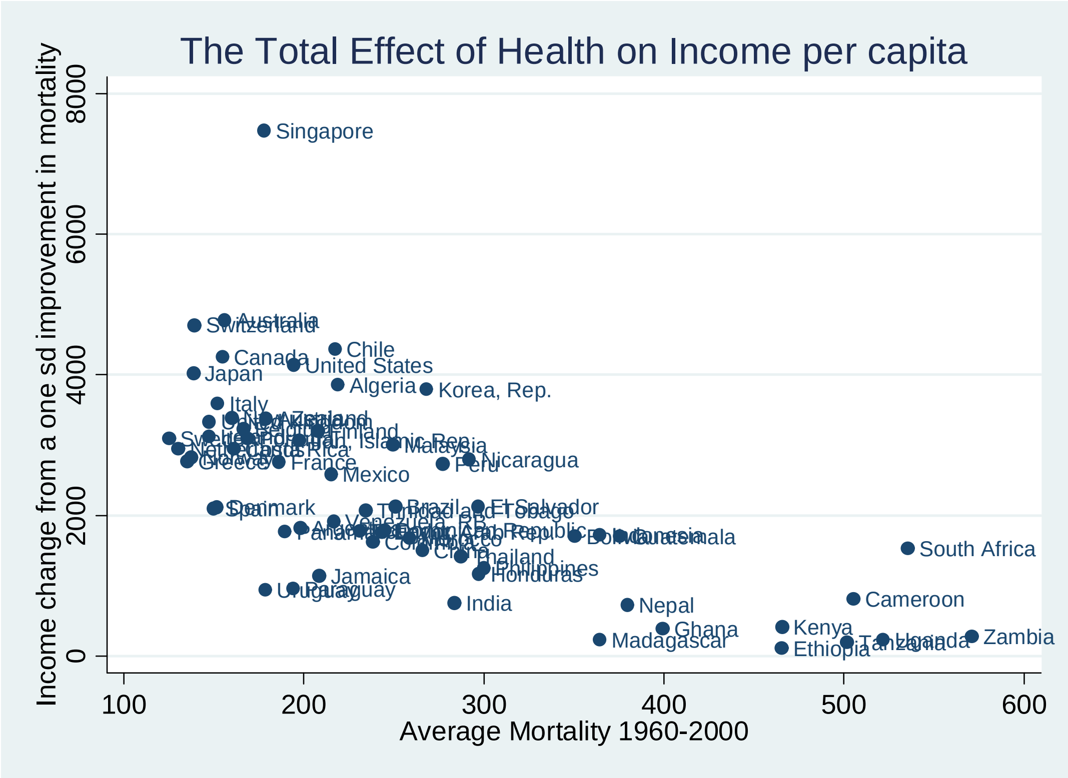

Figure 10: Quantifying the total effect of health improvements on economic development