Cognitive and Economic Development


June 30, 2016

Abstract

Life expectancy has a robust correlation with economic growth in cross-country data. We show that this correlation is due to child mortality, not adult mortality. We investigate whether disease and malnutrition which compromises cognitive development is responsible for the correlation of child mortality with economic growth. Cognitive deficiencies reduce peoples’ economic capabilities throughout their lives, and make investments in education less productive. In an economic growth model we distinguish three consequences of poor health: mortality, morbidity, and cognitive impairment, showing that they are likely to have distinct economic impacts. Cross-country data on average cognitive development (IQ) are significantly correlated with economic growth.

1 Introduction

More than twenty years ago researchers compiled the first comparable data on economic growth for a large number of countries covering many years. One of the surprises was the strong correlation of life expectancy with economic growth, typically stronger than the correlation of education with growth. For instance, Sala-i-Martin et al. (2004) found that life expectancy was the eighth-most robust correlate of economic growth from among 67 considered.\footnote{The second most robust correlate of economic growth in this study is primary school enrollment, but as Pritchett (2001) shows, enrollment is often negatively correlated with schooling levels of adult workers, and average schooling typically does not have a very strong correlation with economic growth in cross-country data.} Life expectancy was interpreted as an indicator of health-related human capital which boosts economic production.

Two pieces of evidence cast doubt on this interpretation. First, strong correlation of life expectancy with economic growth is due to child survival, not adult survival. The death of children is a great human tragedy, but child mortality is unlikely to have a large economic impact because young children require only modest material investments especially in a low income setting. If mortality is interpreted as an indicator of the disease environment of the living, the morbidity of young children should have also small economic effects compared to the morbidity of working adults.
Second, the pattern of microeconomic household studies is opposite the pattern found in cross-country data. Household studies show a modest, though positive, impact of health on household income whereas education has a large impact on household income.

Although a child’s health is unlikely to have a direct impact on economic growth, it can have a profound impact on the child’s cognitive development. There is a voluminous medical literature on the effects of specific diseases and health conditions (like anemia or chronic diarrhea) on cognitive development, as well as well-documented consequences of malnutrition both of general nutrients like calories and protein as well as micronutrients like iron, iodine, and folate for impaired cognitive function (Tulchinsky, 2010). A rapidly growing medical literature, often called the “Barker hypothesis” or “fetal origins hypothesis”, demonstrates the dramatic role of fetal development on later life health outcomes, especially old age diseases. Fetal and childhood health circumstances have clear links to later-life educational and economic outcomes, mostly on the basis of data from high income countries (Currie, 2009).

It stands to reason that the cognitive capability of children would contribute national economic growth when they grow up. In high income countries, even modest differences in fetal and child health conditions have notable effects on the economic success of individuals. In low income countries, debilitating childhood disease and malnutrition are widespread, meaning that obstacles to cognitive development are also common.

We present a model of the relationship of health to economic growth, distinguishing mortality, morbidity and cognitive impairment, which have logically distinct impacts on economic activity. We use cross-country data to estimate the correlation of cognitive impairment with economic growth, using different indicators for cognitive deficiency and different estimation methods.

This paper contributes to the empirical literature on the impact of health on economic development, previously addressed by Barro and Lee (1994), Gallup and Sachs (2001), Bhargava, Jamison, Lau, and Murray (2001), Bloom et al. (2004), Weil (2007), Acemoglu and Johnson (2007), Weil (2014), and Bloom et al. (2014), among others. Heckman (2007) and Marsden (2016) studies the hypothesis that cognitive development plays a significant role in economic development, and were inspirations for this paper. Marsden focuses on cross-country evidence linking parasitic and infectious disease to average national IQ levels, and shows that IQ is correlated with national income levels.

An important theme in the literature is that health leads to income growth through its effects on human capital accumulation, and particularly through education. In this setting, health production can be viewed as an investment and the return on the stock of health capital is spending less time in bad health. The individual derives positive utility from a consumption good while deriving disutility from sick time. Human capital stock can be gained by increasing healthy time (Grossman, 1972) or by increasing time for education (Lucas, 1988). A population in better health is able to accumulate more human capital. Healthy children may spend more time at school and are better prepared to earn high incomes later as adults. Along this line, Sachs and Malaney (2002) show that
malaria can compromise educational attainment by reducing cognitive ability
and lowering school attendance.

There is a vast empirical literature on the effect of diseases on the economy.
The microeconomic evidence from quasi-natural experiments – exogenous
interventions such as by charities – and randomized experiments find strong effects
of controlling diseases on human capital (Bleakley (2007), Fortson (2011), Lucas
(2010)). These studies are however microeconomic studies, and it is not clear
how the insights aggregate into a macroeconomic framework. The macroeco-
nomic empirical evidence is rather mixed: some studies find large positive effects
of controlling diseases (e.g. Bloom, Canning and Fink (2009), and Gallup and
Sachs (2001)); some find the effect to be insignificant (e.g. Acemoglu and John-
son (2007), and Ashraf, Lester and Weil (2009)); and some (Young (2005)) find
that there could also be a paradoxical Malthusian effect where an increase in life
expectancy worsens economic outcomes by decreasing the capital/labor ratio.
The endogeneity problem inherent in these empirical studies imposes a great
challenge for uncovering the true effects of reducing disease.

Individuals often do not take into account the effect of their own behavior on
others (Francis (1997), Geoffard and Philipson (1996), Gersovitz and Hammer
(2004)). Goenka and Liu (2014) have examined an optimal health subsidy in an
environment where individuals fail to consider how their actions affect the overall
disease prevalence. We will extend this analysis to a context with private and
public health expenditures and show that the government should spend more
on health when parents do not take into account the effect of child health on
cognitive deficiency, imposing a negative externality. The analysis provides a
justification for public health investment.

The next section shows that the strong correlation of life expectancy with
economic growth is due to child mortality not adult mortality. Section 3 reviews
the evidence about the impact of disease and nutrition on child cognitive de-
velopment, and cognitive development on educational and labor market outcomes.
Section 4 presents a model of economic growth incorporating separate roles for
mortality, morbidity, and cognitive capacity in economic production. Section 5
shows that parents’ lack of awareness of the effect of disease on cognitive de-
velopment causes an externality. Section 6 presents cross-country evidence of
the correlation of average cognitive development on economic growth. Section
7 concludes.

2 Growth is correlated with child not adult mor-
tality

Life expectancy has a strong correlation with economic growth at a national
level. Life expectancy is a function of mortality, reflecting disease and health
conditions, so life expectancy is frequently used as a readily available measure of
the health status of a country’s population. In studies of the causes of economic
growth, life expectancy is often used as an indicator of the health of the working
Table 1: Correlation of economic growth with survival 

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy</td>
<td>0.091</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[0.024]**</td>
<td></td>
</tr>
<tr>
<td>% Change of life expectancy</td>
<td>5.420</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[1.686]**</td>
<td></td>
</tr>
<tr>
<td>Child Survival Rate</td>
<td>26.249</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[9.727]**</td>
<td></td>
</tr>
<tr>
<td>% Change of child survival rate</td>
<td>21.934</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[8.360]**</td>
<td></td>
</tr>
<tr>
<td>Adult Survival Rate</td>
<td>-3.050</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[3.907]</td>
<td></td>
</tr>
<tr>
<td>% Change of adult survival rate</td>
<td>-0.428</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[1.721]</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-4.648</td>
<td>-21.089</td>
</tr>
<tr>
<td></td>
<td>[1.703]**</td>
<td>[7.334]**</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.08</td>
<td>0.10</td>
</tr>
<tr>
<td>$N$</td>
<td>183</td>
<td>183</td>
</tr>
</tbody>
</table>

* p < 0.05; ** p < 0.01
Robust standard errors in brackets

population, which is part of their human capital.

Table 1 shows the correlation of economic growth with life expectancy in column 1. Economic growth is measured as the linear trend growth rate of GDP per capita from 1980 to 2010 for 183 countries (World Bank, 2016), which is regressed on life expectancy at birth (United Nations Population Division, 2016) in 1980 and the percentage change in life expectancy from 1980 to 2010. Initial life expectancy and change in life expectancy are both statistically significantly correlated with economic growth.

One would expect the health of workers to be specifically related to the mortality of adults rather than the mortality of children. However if we look separately at the survival of adults and children, we find that economic growth is not correlated with adult survival at all and is strongly correlated with child survival. The child survival rate is the probability of surviving from ages zero to 5 and the adult survival rate is the probably of those alive at age 15 surviving to age 60, both calculated from model life tables (U.N. Population Division, 2016). Column 2 of Table 1 shows the regression of economic growth on the initial level and percentage change of child and adult survival over the period 1980 to 2010. Child initial survival and child survival change are both significantly positively correlated with growth, but adult initial survival and adult survival change are
non-statistically significantly negatively correlated with economic growth. This just shows the patterns of correlation in the data, but it casts doubt on life expectancy being a good indicator of health of workers, and also casts doubt on adult health status is a major determinant of economic growth.

3 Cognitive Development

What would explain such a strong correlation between child survival and economic growth? The direct economic loss due to child mortality for children under age five is largely the time of parents and other family members required to raise young children. For this to have substantial effects on economic growth requires a major diversion of family member child care time from other economically productive activities. The organization of the household in low income countries with high child mortality typically mitigates these losses because older children with a low opportunity cost of time share part of the duties, and self-employed household members can often integrate child care into their productive activities. Direct material investments in young children in low income countries are usually modest. This means that the death of young children, despite the tremendous suffering it causes, is unlikely to have large economic consequences.

Likewise the morbidity of young children likely has small economic effects because they are not yet productive workers, and the care of sick children is a modest loss of productive time for family workers in low income countries.

Our hypothesis is that child survival is strongly correlated with economic growth because fetal and child disease and nutrition affect cognitive development which has life-long economic consequences. The cognitive impairment due to poor health conditions need not be profound for it to have significant economic impacts since it will affect the economic productivity of the children throughout their whole working lives. An important channel by which cognitive impairments reduce worker productivity is by reducing their educational attainment. Moreover, if the cognitive level of other workers affects the productivity of everyone, the spillover from cognitive impairment will further reduce national productivity.

There is a large and well-established medical literature on the consequences of pre- and post-natal disease and nutrition on cognitive development. There is also substantial evidence of the effects of cognitive capability on educational attainment and earnings.

4 Model

We modify the original Lucas (1988) model to incorporate childhood disease and cognitive deficits which affect workers throughout their lives. Consider an economy of $L_t$ identical individuals with aggregate production function

$$Y_t = K_t^\alpha (A_t h_t L_t \omega_t)^{1-\alpha}$$

(1)
where \( K_t, A_t, h_t \) are capital stock, technological level and human capital, respectively, and \( \omega_t \) is the amount of time devoted for working. Suppose that the individual is born with some human capital \( h_0 \geq 0 \) and her human capital evolves over time according to

\[
\dot{h}_t = \gamma(x_t)e_t h_t^{\psi}
\]

(2)

where \( e_t \) is fraction of time that the individual spends in education, \( x_t \) is the degree of cognitive deficiency due to childhood disease.

The degree of cognitive deficiency effects human capital according to the function \( \gamma(x_t) : R_+ \rightarrow R_+ \) which is a \( C^\infty \) function in \([\gamma, \bar{\gamma}]\) with \( \gamma'(x_t) \leq 0, \gamma''(x_t) \geq 0, \lim_{x_t \to 0} |\gamma'(x_t)| < \infty, \gamma(x_t) \to \gamma \) as \( x_t \to +\infty \lim_{x_t \to \infty} \gamma'(x_t) \to 0, \gamma(x_t) \to \bar{\gamma} \) as \( x_t \to 0 \). In order to get a closed-form solution, we assume that

\[
\gamma(x_t) = \bar{\gamma} + \frac{\gamma x_t}{1 + x_t} \text{ where } \gamma'(x_t) = \frac{\gamma - \bar{\gamma}}{(1 + x_t)^2} \leq 0
\]

The change in the capital stock is given as

\[
\dot{K}_t = Y_t - C_t - m_t - G_t
\]

(3)

where \( m_t, G_t \) are private and public health expenditure.

As in Lucas (1988), time can either be spent in production (\( \omega_t \)) or in education (\( e_t \)), with the remaining time \( u_t \) lost due to recovery from disease. Assume that

\[
\omega_t + e_t + u_t = 1
\]

(4)

and the recovery time depends on health expenditure

\[
u_t = q(m_t, G_t)
\]

(5)

where \( q : R_+^2 \rightarrow R_+ \) is a decreasing concave function in private and public expenditures. We assume \( q(m_t, G_t) = \exp(-\theta m_t - \eta G_t) \).

Suppose that technical change is given by

\[
g_A = \dot{A}_t/A_t = \beta g_h + g_{\bar{A}}
\]

(6)

where \( g_h \) and \( g_{\bar{A}} \) are human capital and average world technology growth rates. Thus \( A_t = h_t^\beta \bar{A}_t \).

As usual, labor force \( L_t \) growth rate is

\[
\dot{L}_t/L_t = b - d.
\]

(7)

with birth rate \( b \) and mortality rate \( d \).

The individual utility is \( V(c_t, u_t) \) where \( V \) is concave and \( \frac{\partial V}{\partial c} > 0, \frac{\partial V}{\partial u} < 0 \) and \( c_t = C_t/L_t \).
Given $G_t$ and $x_t$, the individual’s problem has a planning horizon $T$ with objective $V$ at time $t = 0$ is

$$\max_{c_t, e_t, m_t, \omega_t} \int_0^T \exp(-\rho t)V(c_t, u_t)dt$$

subject to constraints (1)-(7).

As usual, we express all objects in per capita units,

$$y_t = Y_t/L_t, k_t = K_t/L_t$$

Denote by $g_X$ is the growth rate of any variable $X$. At steady state, $g_X$ is constant.

**Solving the individual problem**

It follows from (1) and (3) that the capital stock and income growth rates are

$$g_K = K_t^\alpha (A_t h_t L_t \omega_t)^{1-\alpha} - C_t/K_t - q(m_t, G)/K_t$$

$$g_Y = \alpha g_K + (1-\alpha)(g_A + g_h + g_L + g_\omega)$$

The growth rate of income per head of the population is

$$g_y = \alpha g_k + (1-\alpha)(g_A + g_h + g_\omega)$$

and the growth rate of human capital is

$$g_h = \gamma(x)e_t.$$  

The current-value Hamiltonian is

$$J = (\ln c_t - \ln u_t) \exp(-\rho t) + \lambda_1 \{ K_t^\alpha [A_t h_t L_t \omega_t]^{1-\alpha} - c_t L_t - m_t - G \} + \lambda_2 \gamma(x)e_t h_t + \lambda_3 (b - d) L_t$$

$$= (\ln c_t + \theta m_t + \eta G) \exp(-\rho t) + \lambda_1 \{ K_t^\alpha [A_t h_t L_t (1 - e_t - u_t)]^{1-\alpha} - c_t L_t - m_t - G \} + \lambda_2 \gamma(x)e_t h_t + \lambda_3 (b - d) L_t$$

The usual optimal conditions are

$$\frac{\partial J}{\partial c} = 0, \frac{\partial J}{\partial K} = -\lambda_1$$

which implies

$$g_c = -\frac{\lambda_1}{\lambda_1} - g_L - \rho = \alpha K_t^{\alpha-1} (A_t h_t L_t \omega_t)^{1-\alpha} - (b - d) - \rho.$$
At steady state, $g_c$ is constant. Thus $\alpha K_t^{\alpha-1}(A_t h_t L_t \omega_t)^{1-\alpha}$ is constant, which means that

$$\alpha(\alpha - 1)g_K + (1 - \alpha)(g_A + g_h + g_L + g_\omega) = 0$$

The next F.O.C.

$$\frac{\partial J}{\partial e} = 0, \frac{\partial J}{\partial h} = -\dot{\lambda}_2$$

implies

$$(1 - \alpha)\lambda_1 K_t^{\alpha}(A_t h_t L_t)^{1-\alpha}(1 - e_t - u_t)^{-\alpha} = \lambda_2 \gamma(x) h_t$$

$$(1 - \alpha)\lambda_1 K_t^{\alpha}(A_t h_t L_t)^{-\alpha}(1 - e_t - u_t)^{1-\alpha} + \lambda_2 \gamma(x) e_t = -\dot{\lambda}_2$$

$$\frac{\gamma(x)}{A_t L_t}(1 - e_t - u_t) + \gamma(x) e_t = -\dot{\lambda}_2 / \lambda_2$$

The next conditions yield

$$\frac{\partial J}{\partial m} = 0 \implies \theta \exp(-\rho t) = \lambda_1$$

$$\frac{\partial J}{\partial L} = -\dot{\lambda}_3 \implies (1 - \alpha)\lambda_1 L_t^{-\alpha} K_t^{\alpha}[A_t h_t(1 - e_t - u_t)]^{1-\alpha} - c_t \lambda_1 + \lambda_3(b - d) = -\dot{\lambda}_3$$

**Proposition:** i) The real growth rates of the model satisfy

$$\frac{\partial g_y}{\partial d} > 0, \frac{\partial g_y}{\partial u} > 0, \frac{\partial g_A}{\partial x} < 0$$

ii) At steady state,

$$\frac{\partial g_y^*}{\partial u^*} = 0, \frac{\partial g_y^*}{\partial x} < 0, \frac{\partial g_A^*}{\partial x} < 0, \frac{\partial g_A^*}{\partial u^*} = 0$$

Proof. See Appendix.

### 5 Externality

Given the individual choices, social planner chooses $x_t$ and

$G_t$ to maximize her utility

$$J^G = \max_{C_t, x_t, G_t} T e^{-\rho t} V(C_t, U_t) dt$$

subject to constraints (1)-(7).

**Proposition:**

$$J(x(0)) < J^G(x(G))$$
6 Cross-country evidence

Our model predicts that mortality and morbidity will have different effects on growth than cognitive impairment. Section 2 above shows that child survival has a strong correlation with economic growth. Since child survival is unlikely to have a direct impact on economic production, we can view this as an indicator of cognitive impairment.

The two most obvious problems with interpreting these correlations in Table 1 as causal determinants of economic growth are omitted variables and reverse causation. It is likely that the initial survival levels are correlated with omitted variables, for example the initial income level of the country or the quality of institutions, which would bias the estimated effect of survival on economic growth. It is also likely that changes in survival are at least partly due to changes in GDP per capita, causing the change in survival to be correlated with the error term and also biasing the coefficients.

The most common method for addressing the problems of omitted variables and reverse causation when estimating the determinants of economic growth is the Barro model (Barro and Sala-i-Martí, 1992). Taking a linear approximation near the equilibrium of a neoclassical growth model, they show that growth of income per worker from time 0 to time $t$, $g \equiv \frac{1}{t} (ln(y_t) - ln(y_0))$, is a function of the growth of technology, $g_A$, and the ratio of equilibrium income per worker, $y^*$, and initial income per worker, $y_0$:

$$g \approx g_A + \theta \ln(y^*/y),$$

where $\theta$ is a constant parameter. Adding a country subscript $i$ and an error term $u_i$, the equation becomes

$$g_i = g_{Ai} + \theta \ln(y_{i}^*) - \theta \ln(y_{0i}) + u_i.$$

Since $g_A$ and $y^*$ cannot be directly observed, $g_{Ai} + \theta \ln(y_{i}^*)$ is approximated by a linear combination of a vector of variables, $X_i$, which are correlated with growth of technology and equilibrium income. The estimating equation is

$$g_i = X_i' \beta - \theta \ln(y_{0i}) + u_i,$$  \hspace{1cm} (8)

where $\beta$ is a vector of unknown parameters.

In our context of exploring the relationship of health and economic growth, one of the $X_i$ variables is life expectancy (or adult and child survival). Including other important correlates of economic growth in the $X_i$ variables, like initial income or institutional quality, helps address the problem of omitted variables. Reverse causation bias is minimized by using the value of correlates at the start of the growth period (at time 0). If there is a feedback from economic growth to the $X_i$ correlates, growth between time 0 and $t$ will affect the correlates after time 0, but not at time 0.

Choosing the right correlates of economic growth for inclusion in $X_i$ is, of course, crucial for convincingly addressing omitted variable bias. It is also endlessly debateable, with many more variables proposed than there are countries.
with data. Since life expectancy is known to be robustly correlated with economic growth in precisely this sort of estimation (Sala-i-Martin et al., 2004), the estimated correlation of life expectancy is probably less sensitive to which additional variables are included than most other correlations.

In addition to life expectancy and initial income per worker, we include two of the most commonly used covariates: a measure of educational human capital, the average years of schooling of people aged 15 and over (Barro and Lee, 2010), and a measure of institutional quality, the Political Risk Index, from the International Country Risk Guide (PRS Group, 2013).²

The data on income per worker are from the Penn World Tables (PWT), version 8.1 (Feenstra et al., 2015). Average income per worker is measured by the purchasing power parity real gross domestic product per worker. The growth of income per worker for 1980-2010 and 1960-80 are calculated as the country-specific least squares linear time trend of the natural log of income per worker using the PWT recommended variable $GDP^{NA}$ for measuring growth rates. Initial income per worker, $y_0$, uses the PWT recommended variable $GDP^{60}$ for measuring income levels.

The results of the growth regressions are shown in Table 2. In the first column, life expectancy in 1980 is statistically significantly correlated with growth in income per worker during 1980-2010, including initial income per worker, the Political Risk Index and average years of schooling of adults. The measure of institutional quality is statistically significant while the measure of education is not, which is a common result in this type of regression.

The second column shows a similar regression covering the same time period with life expectancy replaced by child and adult survival rates in 1980. Child survival has a statistically significant coefficient which is three times larger than the non-significant adult survival coefficient, despite the fact that child survival encompasses only a five year period while adult survival encompasses a forty-five year period of risk. The joint significance of the $F$ test for both survival rates being zero is significant at the 1% level, just like life expectancy.

Column three shows a regression similar to column one, but for an earlier time period, 1960-80. Since the Political Risk Index is not available for this earlier time period, it is left out, but the estimated coefficients are very similar to the coefficients for the 1980-2010 period. Column four repeats the regression in column two for the earlier time period, replacing life expectancy with child and adult survival, and again shows the same pattern. Child survival has a statistically significant coefficient which is much larger than the non-significant adult survival coefficient. The child and adult coefficients are jointly statistically significant at the 1% level.

The Barro-type growth regressions, which do a better job of controlling for omitted variable bias and reverse causation bias than the simple correlations in

²The Political Risk Index (PRI) for each country is a weighted average of the following subindexes: Government Stability, Socioeconomics Conditions, Investment Profile, Internal Conflict, External Conflict, Corruption, Military in Politics, Religion in Politics, Law and Order, Ethnic Tensions, Democratic Accountability, and Bureaucracy Quality. The PRI data are first available for 1984, so we use data for that year instead of for 1980.
Table 2: Barro growth regressions

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln(y_0) )</td>
<td>-1.331</td>
<td>-1.446</td>
<td>-1.421</td>
<td>-1.376</td>
</tr>
<tr>
<td></td>
<td>[0.280]**</td>
<td>[0.296]**</td>
<td>[0.308]**</td>
<td>[0.311]**</td>
</tr>
<tr>
<td>Political Risk Index</td>
<td>0.034</td>
<td>0.040</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[0.012]**</td>
<td>[0.012]**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schooling</td>
<td>-0.050</td>
<td>-0.059</td>
<td>-0.138</td>
<td>-0.094</td>
</tr>
<tr>
<td></td>
<td>[0.091]</td>
<td>[0.089]</td>
<td>[0.130]</td>
<td>[0.134]</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>0.165</td>
<td>0.181</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[0.044]**</td>
<td>[0.029]**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Survival Rate</td>
<td>16.546</td>
<td>12.075</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[6.681]*</td>
<td>[5.182]**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult Survival Rate</td>
<td>5.283</td>
<td>6.598</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[3.490]</td>
<td>[3.416]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.013</td>
<td>-7.766</td>
<td>5.892</td>
<td>0.840</td>
</tr>
<tr>
<td></td>
<td>[1.953]</td>
<td>[3.966]</td>
<td>[2.265]*</td>
<td>[2.849]</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.34</td>
<td>0.36</td>
<td>0.40</td>
<td>0.39</td>
</tr>
<tr>
<td>( N )</td>
<td>88</td>
<td>88</td>
<td>77</td>
<td>77</td>
</tr>
<tr>
<td>( F ) test, both Survival = 0</td>
<td>7.33**</td>
<td>17.63**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* \( p < 0.05 \); ** \( p < 0.01 \)

Robust standard errors in brackets

Table 1, nonetheless show the same pattern. When we replace life expectancy with separate variables for child and adult survival, the child survival variable dominates the correlation with growth. It is larger and more statistically significant than the adult survival variable.

We would like to be able to measure cognitive capability directly and separate its effect from adult mortality and morbidity. We can do that with data on average IQ by country.

Lynn and Meisenberg (2010) present data on average IQ for 93 countries collected from published studies. The data are derived 2.8 studies per country on average, with most combined sample sizes for most countries from 1000-5000 people. The smallest sample size is Norway with one study of 100 people. All other countries have a sample size of more than 200. Most of the studies test school-age children, but a small number test adults.

IQ tests generate relatives scores, so all the test data were scaled relative to British average IQ tests where were assigned a mean of 100 and a standard deviation of 15.
## Table 3: IQ-growth regressions

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln(y_0) )</td>
<td>-1.084</td>
<td>-1.246</td>
</tr>
<tr>
<td></td>
<td>[0.262]**</td>
<td>[0.238]**</td>
</tr>
<tr>
<td>Political Risk Index</td>
<td>0.032</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td>[0.013]*</td>
<td>[0.013]</td>
</tr>
<tr>
<td>Schooling</td>
<td>0.059</td>
<td>-0.099</td>
</tr>
<tr>
<td></td>
<td>[0.089]</td>
<td>[0.079]</td>
</tr>
<tr>
<td>Adult Survival Rate</td>
<td>11.573</td>
<td>4.824</td>
</tr>
<tr>
<td></td>
<td>[3.574]**</td>
<td>[3.512]</td>
</tr>
<tr>
<td>IQ</td>
<td>0.131</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[0.027]**</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.623</td>
<td>-4.131</td>
</tr>
<tr>
<td></td>
<td>[2.201]</td>
<td>[2.037]*</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.29</td>
<td>0.51</td>
</tr>
<tr>
<td>( N )</td>
<td>88</td>
<td>62</td>
</tr>
</tbody>
</table>

* *p* < 0.05; ** *p* < 0.01

Robust standard errors in brackets

There are several flavors of IQ tests, and newer ones have been designed to have no culture-specific content, although some earlier tests are also included in the data. In developing countries in the sample, by far the most common tests are Raven’s Progressive Matrices, which are non-verbal pattern matching tests (Raven, 1936). You can see an example at [www.iqtest.dk](http://www.iqtest.dk).

These data are not perfect for our purposes. The samples of IQ test takers are often not nationally representative, and the studies are carried out at different times. Eighty-three percent of the studies were published in the 1960s to the 1990s, but small numbers were published before or in the early 2000s. In none of the countries used in the estimation sample were all the studies outside the 1960s - 1990s period.\(^3\)

Despite these issues of Wichert et al. (2010) finds the Lynn and Meisenberg country IQ data highly consistent with scholastic achievement surveys (including PISA and TIMSS scores), which is a principal method of evaluating the validity of cognitive tests. Wichert et al. find that the outliers are almost all sub-Saharan African data. They undertake an intense literature search for high quality African IQ test data. Their revised average IQ scores for African coun-

\(^3\)IQ researchers have identified a tendency for mean IQ tests to rise over time, known as the Flynn effect (Flynn, 1987). Since this is interpreted as exogenous change, the data are “corrected” at a rate of 3 IQ points per decade (2 IQ points for Progressive Matrix tests). If this change is due to falling rates of cognitive impairment, this adjustment may make studies conducted at different dates more comparable.
Table 4: IQ-growth regressions

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ln(y_0)$</td>
<td>-1.084</td>
<td>-1.246</td>
</tr>
<tr>
<td></td>
<td>[0.262]**</td>
<td>[0.238]**</td>
</tr>
<tr>
<td>Political Risk Index</td>
<td>0.032</td>
<td>0.024</td>
</tr>
<tr>
<td></td>
<td>[0.013]*</td>
<td>[0.013]</td>
</tr>
<tr>
<td>Schooling</td>
<td>0.059</td>
<td>-0.099</td>
</tr>
<tr>
<td></td>
<td>[0.089]</td>
<td>[0.079]</td>
</tr>
<tr>
<td>Adult Survival Rate</td>
<td>11.573</td>
<td>4.824</td>
</tr>
<tr>
<td></td>
<td>[3.574]**</td>
<td>[3.512]</td>
</tr>
<tr>
<td>IQ</td>
<td>0.131</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[0.027]**</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.623</td>
<td>-4.131</td>
</tr>
<tr>
<td></td>
<td>[2.201]</td>
<td>[2.037]*</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.29</td>
<td>0.51</td>
</tr>
<tr>
<td>$N$</td>
<td>88</td>
<td>62</td>
</tr>
</tbody>
</table>

* $p < 0.05$; ** $p < 0.01$

Robust standard errors in brackets

Countries are no longer outlying. The data used in this paper substitutes Wichert et al.’s scores for Lynn and Meisenberg’s sub-Saharan African countries.

Table 3 presents the results of Barro-type growth regressions similar to those in Section 2. The first column includes the adult survival rate but excludes the child survival rate. As with life expectancy, the adult survival rate has a highly significant positive correlation with economic growth when child mortality is not included.

In column 2, the average IQ score is included and has a highly significant correlation with economic growth. The correlation of the adult survival rate is still positive, but has lost its statistical significance. The correlation of the average IQ level with economic growth, conditional on the other variables in the regression is shown in Figure 1.

7 Conclusion

The debate about the role of health in economic growth in the empirical literature has focused on the correlation of life expectancy with growth. We present evidence that the robust correlation of life expectancy with economic growth is due to child survival, not adult survival, casting doubt on life expectancy as a measure of worker health. We explore the hypothesis that child survival is strongly correlated with growth because it is an indicator of good cognitive
Figure 1: IQ vs. Economic Growth, controlling for other variables

coeff = .13137075, (robust) se = .02702783, t = 4.86
development of children. Healthy cognitive development makes children better able to succeed in building their human capital through education, as well as making them more productive throughout their working lives.

The medical literature has recently emphasized the tremendous importance of the period a child is in utero and an infant for good cognitive development, as well as for susceptibility to health problems in later life. This period of time is very short compared to the length of people’s working lives, so it is not surprising that health conditions which affect cognitive development have a disproportionate impact on economic outcomes relative to exposure to disease as an adult.

Our model of economic growth incorporates the impact of cognitive capacity on the accumulation of human capital and thus worker productivity. The model also incorporates mortality and morbidity, but the impacts of these three factors are quite different. Since we assume that human capital affects the absorption of new technology, cognitive impairment reduces growth both in and out of equilibrium. Morbidity, in contrast, has no effect on economic growth in equilibrium. Mortality has a positive effect on economic growth because it frees up additional capital for the remaining workers, making them more productive.

If parents, who dislike their children and themselves being sick in the model, do not perceive that their children being sick can compromise their cognitive development, there is a significant externality. It seems plausible to assume that ordinary parents do not understand the full consequence of health impacts on cognitive development, which have just been discovered by scientists in recent decades. The social planner who can recognize the effect of health on cognitive capabilities can increase welfare by investing in public health.

Our empirical results show that child survival has a statistically significant correlation with economic growth across countries when controlling for other variables researchers have proposed as important determinants of growth. A more direct measure of cognitive capacity, the country’s average IQ, also has a statistically significant correlation with growth.

If our conclusions are correct, and not already incorporated in health planning, the planners should give higher priority to disease and malnutrition in pregnant women and small children than they do now. Diseases which are important causes of cognitive impairment appear to have large economic consequences in addition to the direct suffering they cause. Health conditions which ensure good cognitive development should be prioritized even relative to those that cause adult and child mortality because the prosperity which results will provide the material means to improve all health in the next generation.

References


