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Alternative Estimates of the Effect of the Increase of Life Expectancy on Economic Growth

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Abstract

Until recently the literature has found evidence of a positive, significant, and sizable influence of life expectancy on economic growth. This view has been challenged by Acemoglu and Johnson (2007). They find no evidence that the large exogenous increase in life expectancy led to a significant increase in per capita economic growth. This paper takes up the modelling and estimation framework presented in Acemoglu and Johnson (2007), and presents alternative estimates on the impact of life expectancy on population, GDP, and GDP per capita by using alternative instrument, timeline, and country groups. The findings suggest that the results differ significantly from that provided in Acemoglu and Johnson (2007); that the generalization of the pessimistic outcomes with regards to the impact of life expectancy on income per capita requires caution; and the increase of life expectancy may have had a positive impact on income per capita growth.

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1. INTRODUCTION

Improvements of health and longevity are not simply viewed as a mere end- or by-product of economic development but argued as one of the key determinants of economic growth, and therefore provide means to achieve economic development and poverty reduction. Until recently the literature has found evidence of a positive, significant, and sizable influence of life expectancy on economic growth.[1] This view has been challenged by Acemoglu and Johnson (2007). They provided an empirical analysis based on the international epidemiological transition, apparently led by the wave of international health innovations and improvements that began in the 1940s, and found that there was no evidence that the large exogenous increase in life expectancy led to a significant increase in per capita economic growth. An instrument was constructed, referred to as predicted mortality, based on the pre-intervention distribution of mortality from 15 major diseases around the world and dates of global interventions. This instrument appeared to have a large and robust effect on changes in life expectancy starting in 1940. Then, it was shown that instrumented changes in life expectancy had a large effect on population, a 1% increase in life expectancy leading to an increase in population of about 1.7-2%, but a much smaller effect on total GDP both initially and over a 40-year horizon. Accordingly, the impact of an increase in life expectancy on per capita income was found to be insignificant or negative.

The political economy consequences of such findings bear critical implications in terms of direct investments in health sectors. Generalization of the pessimistic findings of Acemoglu and Johnson (2007) should be subject to more scrutiny – and this paper contributes towards this. In particular, there is a need for considerable caution in interpreting the results obtained from their framework of analysis for two reasons. First, the nature of the international epidemiological transition that occurred around the 1940s and 1950s was unique and may not be applicable to today's world. The changes in life expectancy that occurred mainly due to the infectious diseases during that time may have different implications than the changes that are being observed in recent times. For example, improvement in life expectancy in the recent decades may not increase the population to the extent that it did during the epidemiological transitions. Second, Acemoglu and Johnson (2007) were unable to include Africa in their baseline analysis owing to lack of data. Africa may be an important source of variation in the data and its inclusion in the sample might have led them to different conclusions. This paper investigates whether the findings of Acemoglu and Johnson (2007) prevail if different instrument, time-lines, and country groups are used.

2. THEORETICAL FRAMEWORK

The modeling and estimation framework resembles Acemoglu and Johnson (2007, pp. 931-934) very closely. The implication of the increase in the length of human life is modeled in a closed-economy Solow type neoclassical growth model. The aggregate production function of the economy *i* at time *t* has constant returns to scale:

$$Y_{it} = (A_{it} H_{it})^{\alpha} K_{it}^{\beta} L_{it}^{1-\alpha-\beta} \quad (1)$$

In the above equation, A_{it}, H_{it}, K_{it}, and L_{it} denote technology, effective units of labour, capital, and the supply of land, respectively; and $\alpha + \beta \leq 1$. The effective units of labour, H_{it}, is given by $H_{it} = h_{it} N_{it}$; where N_{it} is the total population and h_{it} is the human capital per person.

[1] For a survey of this strand of literature, see Husain, 2010.

Labour and land are inelastically supplied and the supply of land is normalized to unity for all countries (i.e. $L_{it} = L_i = 1$). Also, cross-country differences in technology, human capital per person and population are assumed to be constant. Therefore, $A_{it} = \overline{A}_i$; $h_{it} = \overline{h}_i$; and $N_{it} = \overline{N}_i$. Economies face depreciation of capital at the rate $\delta \in (0,1)$ and the savings (investment) rate of country i is constant and equal to $s_i \in (0,1)$. This implies that the evolution of capital stock in country i at time t will be $K_{it+1} = s_i Y_{it} + (1-\delta)K_{it}$; and that after population and the capital stock have adjusted owing to a change in life expectancy from a baseline value X_{it_0} to a new steady-state level X_{it_1}, the steady-state capital stock level will be $K_i = \frac{s_i}{\delta} Y_i$. Substituting into (1) and taking logs we obtain a simple relationship between income per capita, the savings rate, human capital, technology, and population:

$$y_i \equiv \log\left(\frac{Y_i}{N_i}\right) = \frac{\alpha}{1-\beta}\log \overline{A}_i + \frac{\alpha}{1-\beta}\log \overline{h}_i + \frac{\beta}{1-\beta}\log s_i - \frac{\beta}{1-\beta}\log \delta - \frac{1-\alpha-\beta}{1-\beta}\log \overline{N}_i \qquad (2)$$

Equation (2) shows that income per capita is affected positively by technology A_i, human capital h_i, and the investment rate s_i, and negatively by population, N_i.

Acemoglu and Johnson (2007) suggest three channels through which the impact of increased life expectancy is assumed to be working: (a) increased population; (b) increased human capital accumulation; and (c) positive effects on (total factor) productivity. Isoelastic functions are used to capture these effects: $N_{it} = \overline{N}_i X_{it}^{\lambda}$; $A_{it} = \overline{A}_i X_{it}^{\gamma}$; and $h_{it} = \overline{h}_i X_{it}^{\eta}$ - where X_{it} is life expectancy in country i at time t; $\overline{N}_i$, $\overline{A}_i$, and $\overline{h}_i$ are some baseline differences across countries. Using the steady-state value of capital stock, we derive the long-run relationship between log life expectancy and log per capita income below:

$$\begin{aligned} Y_{it} &= (\overline{A}_i X_{it}^{\gamma} \overline{h}_i X_{it}^{\eta} \overline{N}_i X_{it}^{\lambda})^{\alpha} s_i^{\beta} Y_i^{\beta} \delta^{-\beta} \\ \Rightarrow \log(\frac{Y_{it}}{N_{it}}) &= \frac{\alpha}{1-\beta}\log \overline{A}_i + \frac{\alpha}{1-\beta}\log \overline{h}_i + \frac{\beta}{1-\beta}s_i - \frac{\beta}{1-\beta}\log \delta - \frac{1-\alpha-\beta}{1-\beta}\log \overline{N}_i \\ &+ \frac{1}{1-\beta}(\alpha(\gamma+\eta) - (1-\alpha-\beta)\lambda)\log X_{it} \end{aligned} \qquad (3)$$

Denoting $x_{it} \equiv \log X_{it}$ and $y_{it} \equiv \log\left(\frac{Y_{it}}{N_{it}}\right)$, we obtain:

$$\begin{aligned} y_{it} &= \frac{\alpha}{1-\beta}\log \overline{A}_i + \frac{\alpha}{1-\beta}\log \overline{h}_i + \frac{\beta}{1-\beta}\log s_i - \frac{\beta}{1-\beta}\log \delta - \frac{1-\alpha-\beta}{1-\beta}\log \overline{N}_i \\ &+ \frac{1}{1-\beta}(\alpha(\gamma+\eta) - (1-\alpha-\beta)\lambda)x_{it} \end{aligned} \qquad (4)$$

The last term in equation (4) shows that an increase in life expectancy will lead to a significant increase in long-run income per capita when there are limited diminishing returns (i.e., $1-\alpha-\beta$ is small) and when life expectancy creates a substantial externality on technology (high γ) and/or encourages significant increases in human capital (high η). On the other hand, when γ and η are small and $1-\alpha-\beta$ is large, an increase in life expectancy would reduce income per capita even in the steady state.

Equation (4) applies to the long run steady-state scenario where it is assumed that the capital stock has adjusted in the face of change in the life expectancy and resultant changes in other variables, i.e. population, productivity, human capital per worker. Acemoglu and Johnson (2007) also show what happens to output in the "medium run" where the capital stock is constant (or before it has fully adjusted). Considering the impact of a change in life expectancy from any baseline value X_{it_0} at t_0 to a new value X_{it_1} at t_1., and assuming that the capital stock is fixed at some value $\overline{K}_i$ in the face of change in the life expectancy and resultant changes in other variables, we obtain the following log-linear relationship between log life expectancy, $x_{it} \equiv \log X_{it}$, and log income per capita, $y_{it} \equiv \log(Y_{it}/N_{it})$:

$$y_{it} \equiv \beta \log \overline{K}_{it0} + \alpha \log \overline{A}_i + \alpha \log h_i - (1-\alpha) \log \overline{N}_i + (\alpha(\gamma+\eta) - (1-\alpha)\lambda) x_{it} \quad (5)$$

for $t = t_0, t_1$

A comparison of equation (5) to equation (4) demonstrates that the medium-run effect of an increase in life expectancy on income per capita is less positive in the former than the later. It makes sense, because the response to an increase in population before the capital stock adjusts to its new steady-state level will be a reduction in the capital-labor ratio, and thereby reducing income per capita.

3. ESTIMATION FRAMEWORK

Given the modelling framework, the empirical strategy basically is to estimate equations similar to (4) and (5), and compare the estimates to the parameters in these equations. More specifically, fixed effects panel regression method is used to capture the impact of life expectancy on the following major macro variables: population, GDP, and GDP per capita. The fixed effects model examines country differences in intercepts, assuming the same slopes and constant variance across groups. Such models assist in controlling for unobserved heterogeneity, when this heterogeneity is constant over time.

Adding an error term, the generalized version of the estimating equation is:

$$y_{it} = \pi x_{it} + \zeta_i + \mu_t + \varepsilon_{it} \quad (6)$$

where y is log income per capita, ζ_i is a fixed effect capturing potential technology differences and other time-invariant omitted effects (i.e. $\overline{A}_i$, $\overline{h}_i$, $\overline{N}_i$, and $\overline{K}_i$ or $\overline{s}_i$), μ_t incorporates time-varying factors common across all countries, and x is log life expectancy at birth. The coefficient π is the parameter of interest, which is equal to $\frac{1}{1-\beta}(\alpha(\gamma+\eta) - (1-\alpha-\beta)\lambda)$ when equation (4) applies; or, $(\alpha(\gamma+\eta) - (1-\alpha)\lambda)$ when equation (5) applies. It is crucial to include a full set of country fixed effects, the ζ_i's, because the country characteristics $\overline{A}_i$, $\overline{h}_i$, $\overline{N}_i$, and $\overline{K}_i$ or $\overline{s}_i$ would be correlated with life expectancy (or health). Also, many country-specific factors will simultaneously affect health and economic outcomes. Fixed effects at least remove the time-invariant components of these factors. Additionally, the time fixed effect (μ_t) component controls for unobserved omitted variables that changes over time but are constant across entities.

Prior to investigating the effect of life expectancy on income per capita, its effects on population, and total income (i.e. GDP) are reported. The equations for these outcome variables are identical to (6), with the only difference being the dependent variable. It is, however, very much plausible that equation (6) may be beset with the potential omitted

variable bias and reverse causality problem; i.e. there may be the presence of potentially time-varying factors simultaneously affecting health and economic outcomes. In that case the causal effect of life expectancy on income per capita or population would be misleading. In particular, in equation (6), typically the population covariance term $Cov(x_{it}, \varepsilon_{it})$ is not equal to 0, because even conditional on fixed effects, health could be endogenous. In Acemoglu and Johnson (2007), the endogeneity problem has been addressed by exploiting the potentially-exogenous source of variation in life expectancy attributable to global health innovations and interventions. Specifically, the first-stage relationship is:

$$x_{it} = \psi M_{it}^{I} + \widetilde{\varsigma}_i + \widetilde{\mu}_t + u_{it} \tag{7}$$

where M_{it}^{I} is the instrument, termed as predicted mortality, derived from the worldwide variations in the death rates from different diseases, and due to disease specific interventions at different points in time. Similarly in this paper, the first stage relationship is presented in the equation below:

$$x_{it} = \phi V_{it}^{'} + \widetilde{\varsigma}_i + \widetilde{\mu}_t + u_{it} \tag{8}$$

where $V_{it}^{'}$ includes alternative instrument like immunization coverage. $\widetilde{\mu}_t$ represents the time fixed effect controlling for unobserved omitted variables that changes over time but are constant across entities; $\widetilde{\varsigma}_i$ captures entity fixed effect controlling for unobserved omitted variables that differ across countries.

4. ALTERNATIVE INSTRUMENT: IMMUNIZATION PROGRAMMES

In the post epidemiological transition period, one important element of the world-wide large scale health intervention was the programme of immunization. Examples of effective public health programmes, not necessarily hinging upon the national income level, exist to facilitate understanding the determinants of the changes in population health (see for example, Levine et al., 2004; Chandra, 2006). In this light, the cross-country vaccine adoption and implementation rates by diseases may be a more relevant instrument in explaining exogenous variations in life expectancy.

Immunization is a proven tool for controlling and eliminating life-threatening infectious diseases and is estimated to avert over 2.5 million deaths each year. It has clearly defined target groups; it can be delivered effectively through outreach activities; and vaccination does not require any major lifestyle change (WHO, 2005). The Expanded Programme on Immunization (EPI) launched by the World Health Organization (WHO) in 1974 increased immunisation from five percent of all children to 80 percent in a span of thirty years (Tangermann, 2007). This was mainly possible due to coordinated efforts from a coalition of partners: governments, the United Nations Development Programme, UNICEF, development agencies, the World Bank, the Rockefeller Foundation, Medecins sans Frontières, and Rotary International.[2] Since 2000, the GAVI has been very successful at re-focusing immunization

[2] However, the programs could not have been successful without the involvement of political, religious and community leaders, all of whose contribution amounted to what has been described as the greatest social mobilisation effort in peace-time. (http://www.immunisation.nhs.uk/About_Immunisation/Around_the_world /The_Expanded_Program_on_Immunization_EPI; browsed in December, 2008)

activities globally.[3] For people in developing countries, successful immunisation programmes save thousands of lives, and organisations including UNICEF and the WHO are committed to making vaccines against measles, polio and other serious diseases available to as many children as possible. Immunization is therefore one of the most cost-effective public health interventions, with demonstrated strategies that make it accessible to even the most hard-to-reach and vulnerable populations. The cost of fully immunizing a child with the six traditional EPI vaccines through routine health services were estimated to be approximately 15 USD per child in the 1980s and approximately 17 USD per child in the 1990s. Thus, with an annual birth cohort of approximately 91.4 million in low-income countries, estimates of total immunization costs in 1998 were 1.123 billion USD (GAVI, 2000).

Three most widely used vaccinations in the world are (i) *Bacille Calmette Guerin* (BCG), which is effective in reducing the likelihood and severity of TB in infants and young children; (ii) The DPT composite vaccine, which protects against the diseases - diphtheria, pertussis, and tetanus; and (iii) Measles, which is an extremely contagious viral disease that, before the widespread use of measles vaccine, affected almost every child in the world. The vaccination rates (or synonymously immunization coverage), i.e. the percentages of children age 12–23 months who received specified vaccines for the respective vaccines and years, are used as instruments to explain life expectancy.

5. FIRST STAGE ESTIMATES

The first stage relationship, described as $x_{it} = \phi V_{it}^{'} + \widetilde{\varsigma}_i + \widetilde{\mu}_t + u_{it}$, where $V_{it}^{'}$ is immunization coverage, $\widetilde{\mu}_t$ is the time fixed effect, and $\widetilde{\varsigma}_i$ is the country fixed effect, is reported in Table 1. The regressions are run on different sample of countries. These are: (i) "All Countries" – for which data on all the variables are available, (ii) "WB low income countries" – referring to the World Bank (WB) country classification, (iii) "WB Lower Middle Income countries", and (iv) Panel of 59 countries – the core list of countries used by Acemoglu and Johnson (2007).[4] The data on life expectancy at birth, population, real GDP, GDP per capita, and vaccination rates are obtained from the World Development Indicator (WDI, 2007) produced by the World Bank.

The three panels in Table 1 report the results for three of the vaccine groups: BCG, DPT, and Measles vaccines covering the period 1980-2004. The three vaccination variables are used separately because of the very high correlations that exist among them. All the coefficients in Table 1 are significant at less than the 5% level of significance. The corresponding F-statistics for individual coefficients mostly complies with the rule of thumb to be qualified as a strong instrument, which is that they should be more than 10 (see, e.g. Stock and Watson, 2006). The elasticity values for the BCG vaccine coverage range between 0.018 and 0.043 with an average of about 0.032. The elasticity values are very similar for DPT and Measles variables. Highest elasticity values are observed for the WB low income countries (i.e. 0.043, 0.045, 0.046), and lowest elasticity values are observed for the panel of 59 countries, which

[3] GAVI partners include governments in industrialized and developing countries, UNICEF, WHO, the Bill and Melinda Gates Foundation, the World Bank (WB), NGOs, foundations, vaccine manufacturers, and technical agencies such as the US Centers for Disease Control and Prevention (CDC).

[4] The panel of 59 countries used in Acemoglu and Johnson (2007) in terms of the three digit code are the following: Poor Countries (16): BGD, BRA, CHN, ECU, HND, IDN, IND, KOR, LKA, MMR, MYS, NIC, PAK, PHL, SLV, THA; Middle Income Countries (20): ARG, AUT, CHL, COL, CRI, ESP, FIN, FRA, GRC, GTM, IRL, ITA, MEX, NOR, PAN, PER, PRT, PRY, URY, VEN; and Rich Countries (11): AUS, BEL, CAN, CHE, DEU, DNK, GBR, NLD, NZL, SWE, USA.

includes 11 rich countries. The coefficients in general are more significant and the corresponding F-statistics qualifies the variable to be a potential instrument.

Table 1: First Stage Estimates: Life Expectancy and Immunization Coverage

	1	2	3	4
	All Countries 1980-2004	WB Low income countries 1980-2004	WB Lower Middle Income countries 1980-2004	Panel of 59 countries 1980-2004
		Dependent Variable: Log Life Expectancy		
Log BCG	**0.029**	**0.043**	**0.039**	**0.018**
Standard error (Robust)	0.007	0.013	0.013	0.004
t-value	4.29	3.36	2.97	4.21
F-statistics	18.40	11.29	8.83	17.74
Number of observation	776	262	272	253
Number of countries	158	53	55	45
		Dependent Variable: Log Life Expectancy		
Log DPT	**0.028**	**0.045**	**0.04**	**0.024**
Standard error (Robust)	0.006	0.012	0.014	0.004
t-value	5.24	3.69	2.82	5.93
F-statistics	27.44	13.62	7.98	35.21
Number of observation	934	263	282	334
Number of countries	183	53	56	59
		Dependent Variable: Log Life Expectancy		
Log Measles	**0.03**	**0.046**	**0.04**	**0.017**
Standard error (Robust)	0.006	0.014	0.015	0.004
t-value	5.28	3.38	2.74	4.21
F-statistics	27.83	11.44	7.51	17.72
Number of observation	906	257	273	320
Number of countries	183	53	56	59

Note: Regressions with a full set of year and country fixed effects. Robust standard errors, adjusted for clustering by country are reported.

6. MAIN RESULTS: 2SLS ESTIMATES

6.1. LIFE EXPECTANCY AND POPULATION

The instrumented life expectancy in Acemoglu and Johnson (2007) suggests that there is a large, and relatively precise and robust effect of life expectancy on population, irrespective of different country classifications. However, we do not observe similar result reported in Table 2. While relatively large and significant elasticity values are observed in column 1 when the regression is run on all the countries, contrasting estimates are obtained when regressions are run for the low income countries and the lower middle income countries. The impact of life expectancy on population is insignificant and imprecise, particularly for the low income countries.

Table 2: 2SLS Estimates: Impact of Life Expectancy on Population

	1	2	3	4
	All Countries	**WB Low income countries**	**WB Lower Middle Income countries**	**Panel of 59 countries**
	1980-2004	**1980-2004**	**1980-2004**	**1980-2004**
	Dependent Variable: Log Population			
	Panel 1: Life expectancy instrumented by BCG Vaccine Coverage			
Log of life expectancy	**2.467**	**-0.156**	**1.995**	**1.670**
Standard error (Robust)	1.153	0.440	1.205	1.036
t-value	2.140	-0.360	1.660	1.610
Number of observation	760	251	267	253
Number of countries	155	51	54	45
	Panel 2: Life expectancy instrumented by DPT Vaccine Coverage			
Log of life expectancy	**2.536**	**0.137**	**2.586**	**2.405**
Standard error (Robust)	0.761	0.364	1.400	0.812
t-value	3.330	0.380	1.830	2.960
Number of observation	919	253	277	334
Number of countries	180	51	55	59
	Panel 3: Life expectancy instrumented by Measles Vaccine Coverage			
Log of life expectancy	**1.815**	**-0.001**	**1.651**	**1.890**
Standard error (Robust)	0.652	0.324	1.213	0.870
t-value	2.790	0.000	1.360	2.160
Number of observation	890	246	268	320
Number of countries	180	51	55	59

Note: Regressions with a full set of year and country fixed effects. Robust standard errors, adjusted for clustering by country are reported.

6.2. LIFE EXPECTANCY AND GDP

The 2SLS estimates for the impact of life expectancy on GDP are remarkably different from those that we observe in Acemoglu and Johnson (2007). The general finding in Acemoglu and Johnson (2007) suggests an inelastic or negative impact of life expectancy on GDP, or at least a smaller impact of life expectancy on GDP than on population. Furthermore, most of the coefficients are statistically insignificant. Contrasting scenario is observed in Table 3, which presents the impact of life expectancy on GDP using different instrument (i.e. immunization), different country groups, and varying timelines. In most of the cases the GDP response is highly elastic and in many cases the coefficients are precisely estimated with small robust standard errors. For instance, for the low income countries a 1 percent increase in life expectancy results in 2.1 to 2.4 percent increases in GDP.

Table 3: 2SLS Estimates: Impact of Life Expectancy on GDP

	1	2	3	4
	All Countries	**WB Low income countries**	**WB Lower Middle Income countries**	**Panel of 59 countries**
	1980-2004	**1980-2004**	**1980-2004**	**1980-2004**
	Dependent Variable: Log GDP			
	Panel 1: Life expectancy instrumented by BCG Vaccine Coverage			
Log of life expectancy	**1.062**	**2.311**	**2.590**	**2.130**
Standard error (Robust)	1.404	1.015	1.749	2.258
t-value	0.760	2.280	1.480	0.940
Number of observation	662	225	228	253
Number of countries	135	46	46	45
	Panel 2: Life expectancy instrumented by DPT Vaccine Coverage			
Log of life expectancy	**2.019**	**2.436**	**0.239**	**0.330**
Standard error (Robust)	1.007	1.080	1.747	1.732
t-value	2.010	2.250	0.140	0.190
Number of observation	777	227	232	334
Number of countries	152	46	46	59
	Panel 3: Life expectancy instrumented by Measles Vaccine Coverage			
Log of life expectancy	**2.220**	**2.097**	**1.250**	**3.356**
Standard error (Robust)	1.045	0.778	1.945	2.415
t-value	2.120	2.690	0.640	1.390
Number of observation	758	222	228	320
Number of countries	152	46	46	59

Note: Regressions with a full set of year and country fixed effects. Robust standard errors, adjusted for clustering by country are reported.

6.3. LIFE EXPECTANCY AND GDP PER CAPITA

The estimated impact of life expectancy on GDP per capita is reported in Table 4. The coefficient figures are the elasticity values, i.e. the coefficients of log life expectancy, after controlling for country and time fixed effects, using instrumental variables, and different country groups. The estimated coefficients closely follow the pattern of the effects of life expectancy on population and GDP. We find a positive impact on GDP per capita in cases where the impact on GDP is larger (more positive) than on population. All the coefficients for the WB low income countries are significant and show that a 1% increase in life expectancy increases GDP per capita by 2.13 to 2.41%. The estimates for the other country groups are imprecise.

Table 4: 2SLS Estimates: Impact of Life Expectancy on GDP Per Capita

	1	2	3	4
	All Countries	**WB Low income countries**	**WB Lower Middle Income countries**	**Panel of 59 countries**
	1980-2004	**1980-2004**	**1980-2004**	**1980-2004**
	Dependent Variable: Log GDP Per Capita			
	Panel 1: Life expectancy instrumented by BCG Vaccine Coverage			
Log of life expectancy	**-1.105**	**2.408**	**1.294**	**0.460**
Standard error (Robust)	1.953	1.029	1.377	2.279
t-value	-0.570	2.340	0.940	0.200
Number of observation	662	225	228	253
Number of countries	135	46	46	45
	Panel 2: Life expectancy instrumented by DPT Vaccine Coverage			
Log of life expectancy	**-0.332**	**2.228**	**-1.618**	**-2.075**
Standard error (Robust)	1.054	0.969	1.682	1.821
t-value	-0.310	2.300	-0.960	-1.140
Number of observation	777	227	232	334
Number of countries	152	46	46	59
	Panel 3: Life expectancy instrumented by Measles Vaccine Coverage			
Log of life expectancy	**0.703**	**2.134**	**-0.041**	**1.466**
Standard error (Robust)	1.054	0.831	1.870	2.976
t-value	0.670	2.570	-0.020	0.590
Number of observation	758	222	228	320
Number of countries	152	46	46	59

Note: Regressions with a full set of year and country fixed effects. Robust standard errors, adjusted for clustering by country are reported.

7. CONCLUSION

This paper finds positive income effects generated by rising life expectancy. Using the predicted mortality instrument Acemoglu and Johnson (2007) find a robust and large impact of life expectancy on population; a relatively smaller and non-robust impact on GDP; and an insignificant or negative impact on GDP per capita. This paper demonstrates remarkably different results for the low income countries, where the impact of life expectancy on population is insignificant; the impact on GDP is much larger and significant, with a correspondingly large positive impact on per capita GDP. This finding bears critical policy implication in the context that the developing nations unanimously endorsed their long term development objectives in the framework of Millennium Development Goals (MDGs) with the targets of reducing poverty and hunger, improving child and maternal health, curbing the trend of major killer diseases, and achieving trade and economic objectives in environmentally sustainable ways. Following the evidence presented in this paper, policy-makers who are interested in improving economic well-being would have a strong case for considering direct investment in health as one of their options by which to meet their economic objectives.

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