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Richard A. Easterlin

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Richard A. Easterlin
University of Southern California
and IZA

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
E-mail: iza@iza.org

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ABSTRACT

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Although cross section relationships are often taken to indicate causation, and especially the important impact of economic growth on many social phenomena, they may, in fact, merely reflect historical experience, that is, similar leader-follower country patterns for variables that are causally unrelated. Consider a number of major advances ("revolutions") in the human condition over the past four centuries – material living levels, life expectancy, universal schooling, political democracy, empowerment of women, and the like. Suppose that each has its own unique set of causes, and, as a result, a unique starting date and a unique rate of diffusion throughout the world. Suppose too that initially all countries are fairly closely bunched together on each variable in fairly similar circumstances. Suppose, finally, that the *geographic* pattern of diffusion is the same for each aspect of improvement in the human condition, that is, the same group of countries have a head start, and the follower countries in the various parts of the world fall in line in a similar geographic order. The result will be statistically significant international cross section relationships among the various phenomena, despite their being causally independent. The oft-reported significant cross-country relationships of many variables to economic growth may merely demonstrate that one set of countries got an early start in virtually every "revolution", and another set, a late start.

JEL Classification: C2, O10, O57, J11, N0, I0

Keywords: cross section, time series, economic growth, life expectancy, diffusion

Corresponding author:

Richard A. Easterlin
Department of Economics
KAP 318B
University of Southern California
Los Angeles, CA 90089-0253
USA
E-Mail: easterl@usc.edu

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Introduction

Among Paul Demeny's many accomplishments is the fact that he has made Population and Development Review the most frequently read journal by demographers (van Dalen and Henkens 2012). An important reason for this achievement has been Paul's willingness to publish "thought pieces", a rare virtue among editors of scientific journals. This brief essay is offered in this vein, as a tribute to Paul's openness, breadth, and vision.

International cross section regressions on real gross domestic product (GDP) per capita are widespread in the social sciences. Findings of significant associations with GDP per capita of a multitude of economic, social, and political variables are commonplace, and these results are often read as indicating the effect of economic growth on the variable(s) under study (Easterlin and Angelescu 2012). For variables integral to production and consumption, such as material living levels or the rural-urban distribution of employment, such inferences are plausible. But economic growth is often viewed also as the main force responsible for such things as the expansion of schooling, improved health and life expectancy, fertility decline, women's empowerment, the extension of political and civil rights, and the like.

Moreover, these cross section relationships are often taken to be predictive of time series change, of what is likely to happen as a result of economic growth. Studies of the actual historical experience of individual countries, however, frequently fail to confirm expectations based on cross section relationships (Easterlin and Angelescu 2012, Easterly 1990). As one moves outside the purely economic realm to social and political variables, this lack of confirmation of an association with GDP per capita is especially apparent. Why, then, is there a significant cross section relationship, if, in fact, the implied causal connection is not confirmed by time series analysis? The answer suggested here is that cross sections register the results of history, not insights into likely experience.

The head start hypothesis

To focus the discussion, take as a demographic example the international cross section regression of life expectancy at birth (e_0) on GDP per capita (Figure 1). This relationship is sometimes thought to demonstrate the causal impact of economic growth on life expectancy, as proclaimed, for example, in the title of the Pritchett and Summers (1996) econometric analysis of international data, "*Wealthier is Healthier*."

Thanks to the seminal work of Samuel Preston (1975), demographers for many years have, instead, viewed the life expectancy difference between rich and poor countries in Figure 1 as the outcome of two component factors – the first, a movement along a given e_0/GDP function, reflecting the positive impact of improved living levels due to economic growth (Pritchett-Summers effect), and the second, an upward shift in the function, the result of advances in health knowledge and technology, whose application leads to increased life expectancy at given levels of GDP per capita. Preston's empirical analysis identified the principle cause of life expectancy improvement post-1900 as the upward shift of the function; indeed, advances in health technology were estimated to account for 75 to 90 per cent of the overall improvement.

Unlike the common "black box" treatment of production technology in economics, Preston offered numerous specific examples of advances in health technology. Other scholars have provided similar evidence (see, e.g., Durand 1960, Easterlin 2004, Cutler et al 2006, and the references therein). The major breakthroughs in health technology occurred roughly in three stages. The first was new methods of preventing the transmission of disease starting around the middle of the nineteenth century. The so-called "sanitation revolution" at that time aimed at cleaning up cities through purer water supplies, better sewage disposal, paved streets, education in personal hygiene, and the like. The second stage, starting around the 1890s, was the introduction of vaccines aimed at preventing certain infectious diseases. The third was the development of new drugs (antimicrobials) to cure infectious disease beginning in the late 1930s. These advances, it should be noted, are quite different from the new technologies of the "industrial revolutions" responsible for the growth of GDP per capita (cf. Easterlin 1996).

A case could be made that *all* of the observed improvement in life expectancy is the result of advances in health technology. Preston's 10 to 25 per cent share of causality allotted to higher GDP per capita is based on a positively sloped e_0/GDP function. But if one were to go back to the mid-nineteenth century, before the great breakthroughs in health knowledge and technology mentioned above, it is by no means clear that the slope of the function was positive at that time. True, higher

GDP per capita meant better food, clothing, and (perhaps) shelter, and hence more resistance to disease. Counteracting this, however, was the fact that higher GDP per capita also led to increased urban concentration, and consequently greater exposure to disease. Nineteenth century economist Nassau Senior's reaction to the horrifying descriptions of Britain's "great towns" in the 1838 Poor Law Reports tells the story:

> What other result [high urban mortality] can be expected, when any man who can purchase or hire a plot of ground is allowed to cover it with such buildings as he may think fit, where there is no power to enforce drainage or sewerage, or to regulate the width of the streets, or to prevent houses from being packed back to back, and separated in front by mere alleys and courts, or their being filled with as many inmates as their walls can contain, or the accumulation within and without, of all the impurities which arise in a crowded population? (as quoted in Flinn 1965).

It seems plausible that the positive slope of Preston's e_0/GDP function was itself the product of new knowledge, because sanitary reform and similar advances gradually eliminated the sizeable excess of urban over rural mortality. Thus, the negative effect on life expectancy that growing GDP per capita induced via increased urban concentration of the population was removed, leaving only the positive effect of improved living levels.

By this reasoning, all of the modern improvement in life expectancy is due to advances in health technology, not to higher GDP per capita. But if this is so, how can one account for the positive association of life expectancy and GDP per capita in Figure 1?

One argument is that the higher income resulting from modern economic growth is essential to financing increased private and government expenditures associated with improved health technology. But the measures necessary to implement advances in health technology do not seem to have required, on average, particularly high levels of income. If they did, then less developed countries (LDCs) would have been hard put to implement public health programs in the twentieth century without substantial external aid. In fact, such aid was trivial; an assessment published in 1980 concluded that "total external health aid received by LDCs is less than 3% of their total health expenditures" (Preston 1980). Clearly, despite their low levels of income, LDCs were able almost entirely on their own to fund applications of new health technology. Higher GDP per capita was not essential to implement these advances.

An alternative explanation – what might be called "the head start hypothesis" – is suggested here for the significant positive cross section association between life expectancy and GDP per capita. Assume that the historical trajectories of GDP per capita and life expectancy are independent of each other and that each is governed by advances in its own underlying technology – in the case of GDP per capita, call it "production technology"; in the case of life expectancy, "health technology" (cf. Easterlin 1996). Assume also that the initial levels of GDP per capita and life expectancy are on the low side and fairly similar among countries, and that the take off dates for advances in production technology and health technology in any given country may differ from each other. Suppose now that the countries with a head start in production technology and thus in the growth of GDP per capita, are the same as those with a head start in health technology, and thus in the improvement of life expectancy. Then the result will be that at any given date the head start countries will have both higher GDP per capita and higher life expectancy than the follower countries, even though GDP and life expectancy have no causal relation to each other. The positive cross section relationship between life expectancy and GDP per capita is the result of the same countries having a head start in the technology underlying each variable.

To illustrate numerically, consider the take off dates in economic growth and life expectancy improvement (reflecting, respectively the introduction of modern production technology and health technology) listed for each of the three regions in Table 1 (columns 1 and 2). Though not precise, the dates are roughly in keeping with historical experience. Western Europe (and its overseas descendants) lead the way in both technologies and Sub-Saharan African brings up the rear. If one calculates years since takeoff in both life expectancy and GDP per capita, Western Europe has the greatest number of years and Sub-Saharan Africa, the least (columns 3 and 4). If one then plots years since takeoff for the three regions, as in Figure 2, we reproduce the positive slope of the regression line in Figure 1. The interpretation of Figure 1 suggested by Figure 2 is that Western Europe has the highest life expectancy and GDP per capita because it had a substantial head start in the implementation of both technologies. Correspondingly, Sub-Saharan Africa has the lowest life expectancy and GDP per capita because it was the last to implement both technologies. The high values on life expectancy and GDP per capita for Western Europe, and low values for Sub-Saharan Africa do not indicate a causal relation – by assumption they are independent of each other. They simply indicate that Western Europe was the leader in both technologies, and Sub-Saharan Africa, a follower. Although the timing and rate of spread differs between the two technologies, the geographic pattern of diffusion is the same, and the result is a statistically significant international cross section.

Discussion

The geographic diffusion of both the Industrial Revolution (i.e., modern economic growth) and the Mortality Revolution (i.e., the modern improvement in life expectancy) is marked by the same leader-follower sequence, with Western European countries and their overseas descendants in the vanguard and Sub-Saharan Africa bringing up the rear. The result is that any point-of-time comparison of countries in recent decades will show a significant positive relation between life expectancy and GDP per capita, with Western Europe and its descendants high on both variables and Sub-Saharan Africa low. Although some analysts take this association as support for a causal connection running from economics growth to life expectancy, this inference is belied by two empirical observations. The first is the substantial difference in the timing of the onset of each phenomenon – while the Industrial Revolution dates from the early nineteenth century, the Mortality Revolution does not take off until over half a century later. The second is the marked difference in the rapidity of spread of the two revolutions. Although the

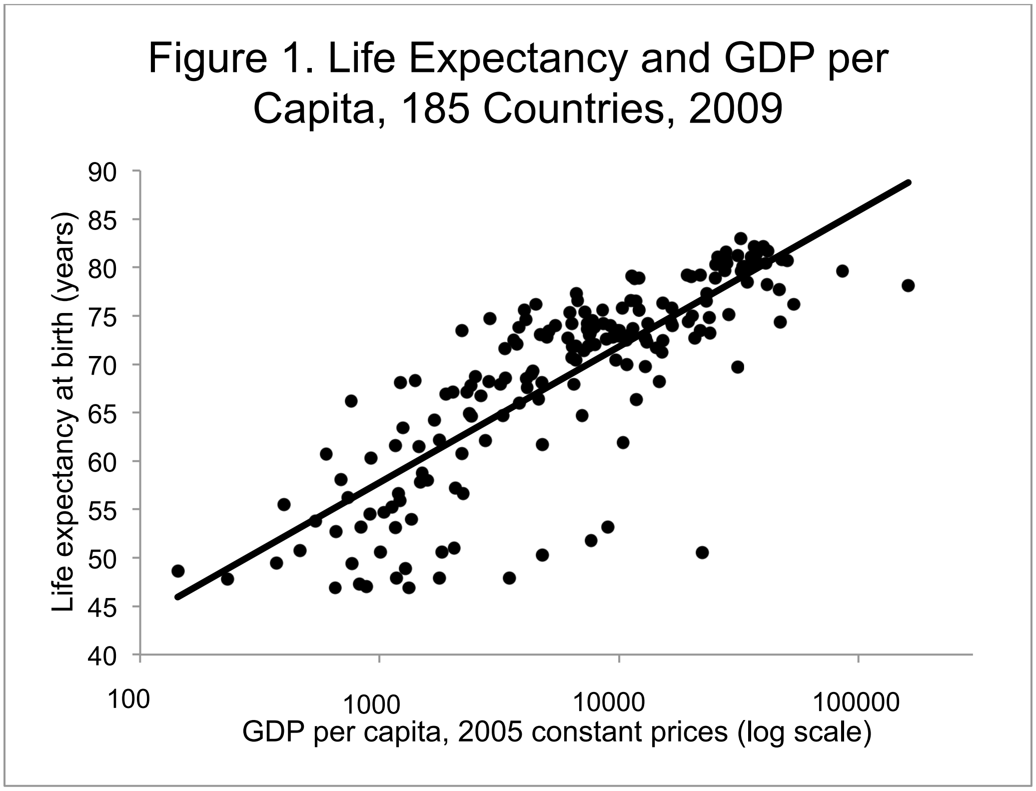
Mortality Revolution starts later, it spreads much faster. By the latter part of the twentieth century the Mortality Revolution had clearly reached Sub-Saharan Africa; whether the Industrial Revolution has taken hold there yet remains arguable. These empirical observations suggest that each revolution must be analyzed in its own right in order to understand its underlying causes and spread. The presumption based on international cross section regressions that growth is the motive force – that "Wealthier is Healthier" – is misleading. Cross section regressions are merely recording that one set of countries got an early start on both revolutions and another set, a late start.

These conclusions, illustrated here for the Industrial and Mortality Revolutions, are more generally applicable. In the past several centuries Western Europe has been in the forefront of a number of revolutionary changes – the development of universal schooling, the rise of political democracy, the adoption of deliberate fertility control and consequent decline in child-bearing, the empowerment of women, the welfare state, and so forth. Each of these is characterized by a unique pattern of onset and spread. For example, while the expansion of public schooling and the rise of political democracy both antedate the onset of modern economic growth, universal primary schooling is today widespread throughout the world, while the diffusion of political democracy remains quite limited. Understanding these patterns calls for much more than simple cross section regressions.

There remains, of course, the question why Western Europe in recent centuries has been the birthplace of what are viewed by many as major advances in the human condition. A plausible starting point is the Scientific Revolution. The new empirical and experimental mode of inquiry it initiated turned out to be the key to systematic knowledge of the natural world and, in time, the social world as well. The benefits of this knowledge have resulted in unprecedented improvements in human well-being, the evidence for which is documented, but not explained, by cross section regressions.

Table 1. Illustrative Take-Off Dates for Modern Economic Growth and Life Expectancy Improvement, Specified Geographic Regions

Region	(1) Date of takeoff: Economic growth	(2) Date of takeoff: Life expectancy	(3) Years from takeoff to 2010: Economic growth	(4) Years from takeoff to 2010: Life expectancy
Western Europe	1820	1890	190	120
East Asia, excluding Japan	1950	1950	60	60
Sub-Saharan Africa	2000	1970	10	40



Note: The fitted regression is: y=6.10x +15.68 where y=life expectancy in years, x=log GDP pc.

(19.16) (5.58)

Adj R^2= 0.6741, N=185. (t-stats in parentheses)

Sources: GDP per capita, Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 7.0, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, May 2011. Life expectancy at birth, UNDP International Human Development Indicators, available at: http://hdr.undp.org, accessed on 06/26/2012.

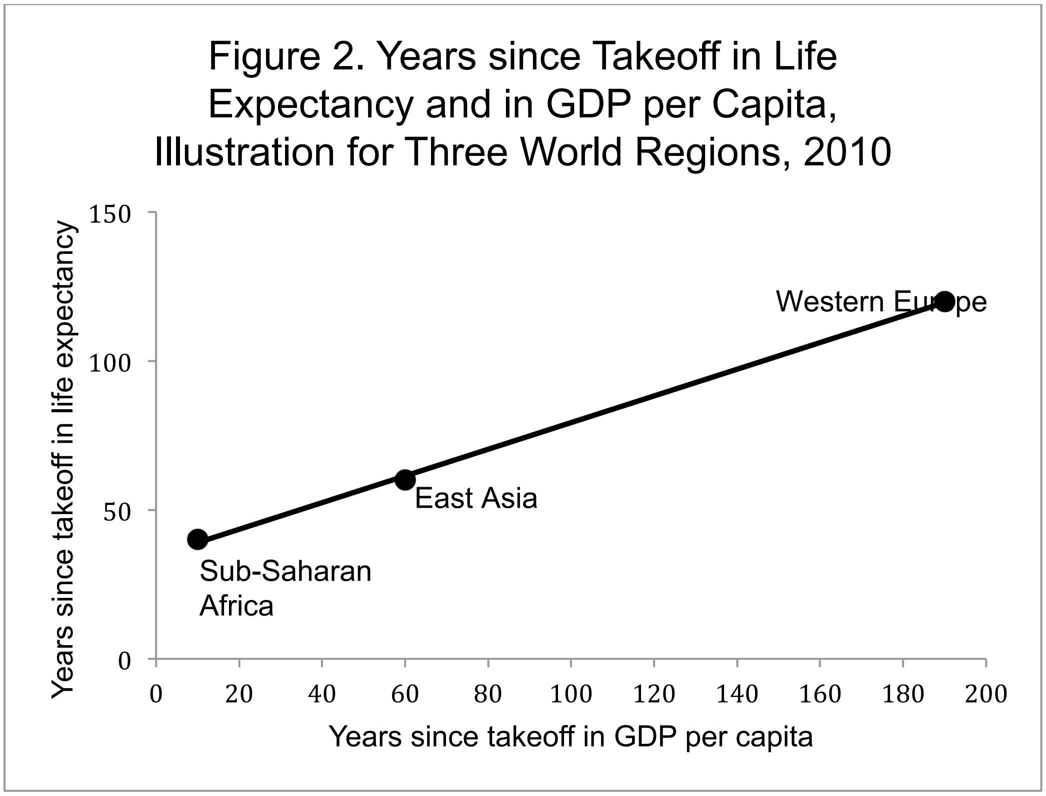


Figure 2. Years since Takeoff in Life Expectancy and in GDP per Capita, Illustration for Three World Regions, 2010
Years since takeoff in life expectancy
150
100
50
0
0
20
40
60
80
100
120
140
160
180
200
Years since takeoff in GDP per capita
Western Europe
East Asia
Sub-Saharan Africa

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