FEWER, RICHER, GREENER
The end of the population explosion and the future for investors

Laurence B. Siegel[1]

The world has been going to hell in a handbasket for as long as anyone can remember, but it never quite seems to get there. In fact, according to just about any objective measure you choose, the health and wealth of the human race has been improving rapidly and almost continuously for at least the last 200 years.[2] There is every reason to expect this trend to continue, most dramatically in the developing world but also, more slowly, in the developed world. Contributing to this favorable economic outlook is the astonishing fact, too little appreciated, that the population explosion is almost over, and that, sometime in our children's or grandchildren's lifetimes, world population will reach a peak between 10 and 11 billion and then either level off or begin to decline.

This world of fewer and richer people will also be greener.[3] Environmental quality is an economic good like any other. The only societies that can afford to pay for large helpings of environmental quality are rich ones. The whole point of getting rich is to buy things one wants. Nearly everyone wants a beautiful, clean, and safe natural environment, but people want other things too — to eat, for example. The human body demands three meals every day. When calories are scarce, future benefits are discounted at very high rates — all you care about is the present. When calories and other necessities are abundant, one can invest in the future, including in environmental quality. The tendency of societies to become environmentally cleaner as they pass a certain threshold of affluence is well documented and is referred to by economists as the environmental Kuznets curve (EKC). We will look at this phenomenon more closely later in this article.

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[2] The economist's traditional view is that "take-off" into self-sustaining development occurred around 1820 in what is now the developed world; see Rostow [1956]. Angus Maddison [2007, 2009], whose work on historical GDP by country over the last two thousand years is considered authoritative, portrays a gentler discontinuity but supports the general idea of a significant increase in growth rates around 1800.

[3] Either "fewer" than the peak population in the sense of an absolute decline in the world's population, or fewer than most people are expecting. "Fewer" in my title is a reference to Wattenberg [2004], who made the case for an absolute decline, which was in the medium-fertility UN Population Division forecast that was available at the time.

My thesis is at odds with most received opinion about the future. A very large body of both popular and scientific literature suggests that natural resource constraints, climate change, and other "limits to growth" will cause the future to be crowded, poor, and dirty. Ridley [2010] has noted that the tradition of pessimism among intellectuals of all stripes — literati, scientists, economists – runs very deep. (Maybe, as Peter Bernstein once said, pessimists just sound smarter and more erudite: the archetype of the wise man or woman reciting a cautionary tale to a foolish optimist goes back at least as far as Aesop.) Economists have been among the least pessimistic of this bunch, because they understand the concepts of substitution, incentives, and growth. Yet many economists and market forecasters today see little in the future to look forward to. They are almost certainly wrong.

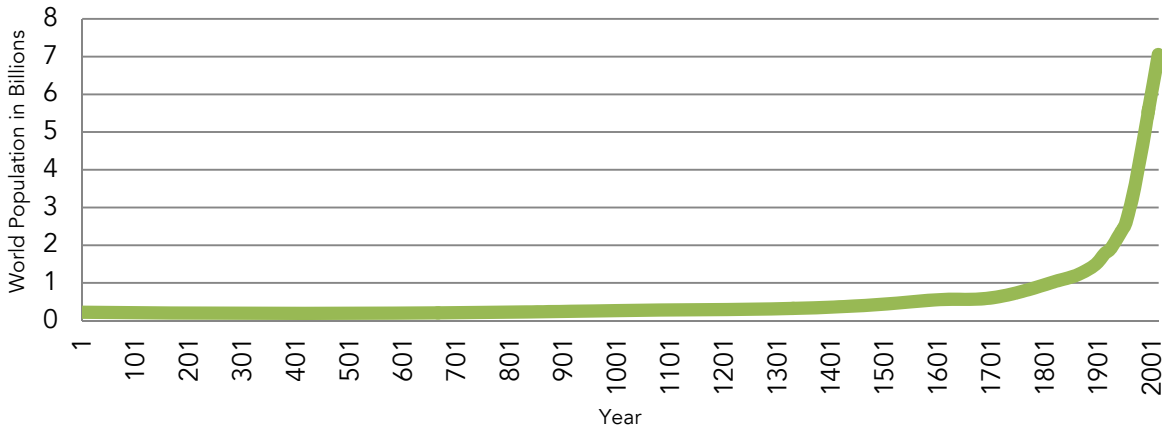
Economic growth and environmental remediation do not happen by magic. They involve hard work, ingenuity, and wisdom; and there will be setbacks, some of them on a large scale. But the incentives for wealth-building are overwhelming. No one, having tasted wealth, wants to return to poverty; and, having seen others become rich, most people, if not all, will do what is necessary to have a chance at becoming rich themselves. It's human nature, which does not change very much over time.[4]

Fewer

As this is being written, the world population has just passed seven billion, up from six billion only 13 years ago, and 1.5 billion at the turn of the last century. The impression of out-of-control population growth is hard to avoid. The popular conception of historical world population growth looks like this:

Figure 1

Historical Population Growth on Arithmetic Scale, Year 1 to 2012



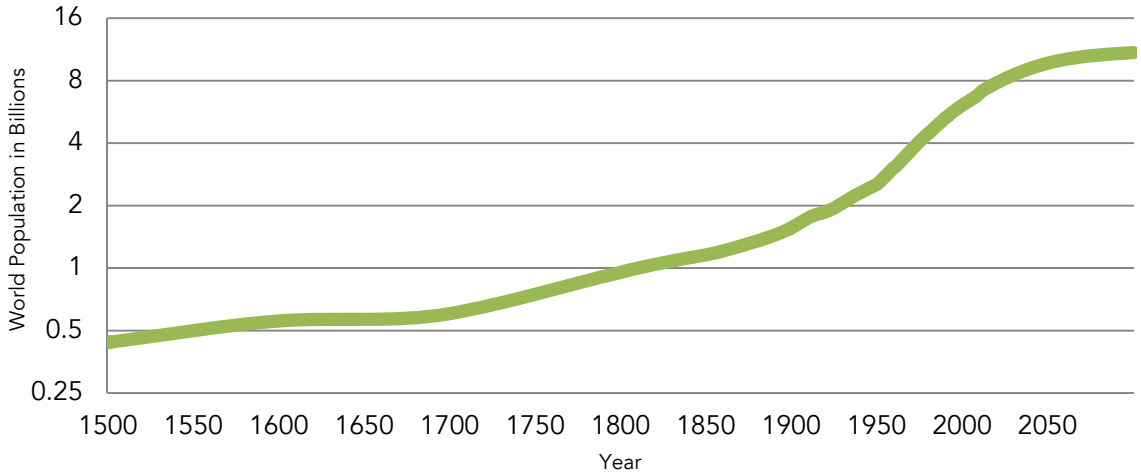
Source: Data through 2008 from Maddison [2009]; author's updates to 2012; interpolations using interp() function from xlxtrfun.com.

[4] That said, civilizations do collapse, and ours could too. Capitalism and economic development have, however, become globalized to an extent that makes it seem unlikely to us that the entire world will lapse into long-term economic decline. Any given region or subset of the world economy could, of course, experience such a decline.

This figure is accurate, yet the arithmetic scale on which it is drawn conceals a vitally important fact: the population growth rate first accelerated, but more recently it has begun to decelerate dramatically and, according to projections based on current fertility rates, the world's population will level off around 11 billion near the end of this century and then, possibly, begin to decline. Here are the same data, but starting in 1500 with projections to 2100, on a log scale:

FIGURE 2

HISTORICAL AND FORECAST POPULATION GROWTH ON LOGARITHMIC SCALE



Source: Data through 2008 from Madison [2009]; author's updates to 2012; UN Population Division medium-fertility projections to 2100 (based on 2010 revision). Interpolations using interp() function from xlxtrfun.com.

Clearly, how you are likely to react to the information depends on how I draw it. An arithmetic scale says that each person counts the same as every other — an argument with which we can all be sympathetic. But, if we want to portray the economic impact of change over time and if we want to make accurate forecasts, the log scale used in Figure 2 may be more useful. This latter figure also paints a much more benign picture, not just because of the log scale but also because I have included projections for 2013-2100. We see that population growth rates have been high for a long time, not just in the very recent past. Since, as investors, we care only about the future, the dramatic deceleration at the end (only a hint of which is visible in Figure 1) is vitally important. In constructing Figure 2, I have used the 2010 revision of the UN Population Division's medium-fertility projections, which do not envision an actual decline in world population, but some UN projections, including the previous (2002) rendition of its medium-fertility projections, do.[5]

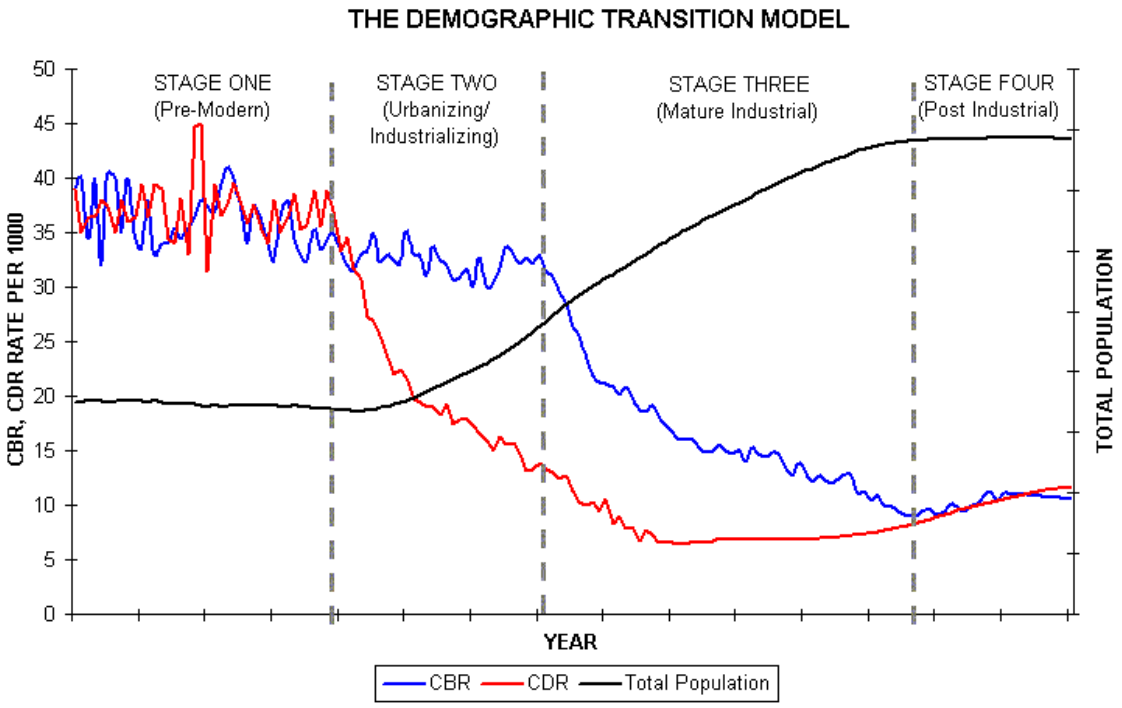
[5] Before the 2010 upward revision of the UN Population Division's projections, the medium-fertility forecast projected an actual decline in the world's population later in this century; with the 2010 revision, the low-fertility forecast still does (while the high-fertility forecast projects a world population of 15 billion in 2100). Wattenberg [2004] cites demographers forecasting depopulation on a massive scale, with the world population reaching 3 billion by 2300. While I think that 300-year forecasts are ridiculous, the fact that population stabilization is widely agreed upon, and that the extent of subsequent decline, if any, is a source of contention, shows the extent to which the population explosion can be considered to be nearing its end.

Why has population growth slowed? A satisfactory answer depends on understanding why it was high in the first place. Figure 3 is a stylized representation of the "demographic transition," the pattern by which birth rates, death rates, and population change as a society industrializes. (Population is the black line, the crude birth rate (CBR) is the blue line, and the crude death rate (CDR) is the red line.) Pre-industrial societies (stage 1) experience both high birth rates and high death rates, which tend to equilibrate so that population does not change much, because limits on the food supply and other resources impose a maximum on the population that can be supported.

As an economy begins to develop (stage 2), the death rate falls quickly because many deaths can be prevented due to easily implementable public health measures and an improved food supply. The birth rate does not fall as quickly, however, because parents do not immediately become aware of the changing incentive structure that they face.

FIGURE 3

THE DEMOGRAPHIC TRANSITION



Source: Keith Montgomery, professor of geography and geology, University of Wisconsin, Marathon County, accessed at http://www.marathon.uwc.edu/geography/demotrans/demtran.htm on December 29, 2011.

The decline in the birth rate, which occurs somewhat more slowly, is a result of the response to changing incentives. In pre-industrial societies, having a large number of children (with the hope that at least a few survive to adulthood) is insurance against penury in old age. Having children is cheap, and *not* having children is expensive (it's a hazardous strategy with a large opportunity cost). In an industrial or post-industrial society, however, having children is expensive — they cost a lot to educate, do not produce much for decades, and may or may not choose to support their parents in old age. Meanwhile, not having children is a reasonable choice; government and the financial markets provide an alternate means of securing retirement income. When people respond to the incentives inherent in an advanced economy (stages 3 and 4), then, they do so by having a very small number of children, one or two.

And this transformation has taken place not only in developed countries but also in many emerging markets. Table 1 shows the total fertility rate (the lifetime number of children per woman) in various countries as of 1950-1955 and as of 2005-2010 (the most recent time period for which data are available). The most remarkable fact is the extent to which fertility rates have fallen *everywhere*.

Many readers are already aware that many European countries plus Japan and Russia already have fertility rates below the replacement rate of 2.1 — the rate at which a couple replaces itself, with the extra 0.1 representing children who do not live to reproductive age — although not everyone is aware how low the lowest fertility rates really are, or how profound the resulting social changes will be. (A world with no Italians won't have much good cooking.) The effects of China's unevenly applied one-child policy are also well known. The U.S., benefiting from immigration and an economy that grew strongly for decades before the crash of 2008, has a higher fertility rate than the countries noted above but is also near "replacement rate."

But the relatively low population growth rates in India, Indonesia, Thailand, Mexico, Brazil, and so forth, are more surprising. While India is still mostly very poor and the other countries in this list are still poor by First World standards, they have progressed enough to begin to offer advanced-country tradeoffs to parents deciding how many children to have. The only large areas that still have high population growth rates are sub-Saharan Africa and the Middle East, and these growth rates will not persist forever either. Due to the natural resources boom, Africa's economies are currently experiencing some of the fastest growth in the world, which will lead to population stabilization over time (but later than in other regions, because Africa's population is so young).

TABLE 1

TOTAL FERTILITY RATES IN SELECTED COUNTRIES AND REGIONS 1950-1955 & 2005-2010

Major area, region, or country	Total fertility (children per woman) 1950-1955	2005-2010	Major area, region, or country	Total fertility (children per woman) 1950-1955	2005-2010
WORLD	**4.95**	**2.52**	**EUROPE AND RUSSIA**	**2.65**	**1.53**
More developed countries	2.81	1.66	France	2.76	1.97
Less developed, excluding least	6.01	2.41	Germany	2.16	1.36
Least developed countries	6.54	4.41	Italy	2.36	1.38
AFRICA	**6.60**	**4.64**	Poland	3.62	1.32
Egypt	6.37	2.85	Russian Federation	2.85	1.44
South Africa	6.50	2.55	Spain	2.53	1.41
Nigeria	6.35	5.61	Sweden	2.21	1.90
ASIA AND ASIA MINOR	**5.58**	**2.28**	Switzerland	2.31	1.46
Bangladesh	6.62	2.38	Ukraine	2.81	1.39
China	5.48	1.64	United Kingdom	2.18	1.83
Hong Kong, China	4.72	0.99	**WESTERN HEMISPHERE**	**5.86**	**2.30**
India	5.90	2.73	Argentina	3.15	2.25
Indonesia	5.67	2.19	Brazil	6.15	1.90
Iran	6.93	1.77	Canada	3.65	1.65
Israel	4.28	2.91	Chile	4.95	1.90
Japan	2.16	1.32	Colombia	6.76	2.45
Malaysia	6.23	2.72	Mexico	6.70	2.41
Pakistan	6.60	3.65	Peru	6.85	2.60
Philippines	7.27	3.27	Puerto Rico	4.97	1.83
Saudi Arabia	7.18	3.03	United States of America	3.45	2.07
Singapore	6.34	1.25	Venezuela	6.46	2.55
South Korea	6.33	1.29	**OCEANIA**	**3.81**	**2.49**
Thailand	6.14	1.63	Australia	3.18	1.93
Turkey	6.30	2.15	New Zealand	3.69	2.14
Vietnam	6.76	1.89			

Source: UN Population Division, 2010 revision, accessed at http://esa.un.org/unpd/wpp/Excel-Data/fertility.htm on January 6, 2012.

Referring back to Figure 2, one can see that overall population growth rates have not fallen on a scale that one might expect given plummeting fertility rates. The reason is *population momentum*, which is a fancy way of saying that, once born, people tend to hang around for a long time (that's a good thing). Thus, the impact of a fertility change today on overall population is felt over the next generation or so, rather than immediately. The intuition behind this is that a population that has recently experienced a decline in the fertility rate — from say, a rate above replacement to one below it – will continue to grow for while, because of the large number of young couples of childbearing age who were born before the fertility rate declined.[6]

Is population stabilization desirable? Of course it is. A few thinkers regard "peak population" and a subsequent possible decline as bad news; Wattenberg [2004], for example, writes in melancholy tones about a world of old people pinning their hopes

[6] Today's low developed-country fertility rates could, of course, rise. There is some evidence of an uptick in fertility as a population becomes very affluent. If children are a luxury good in an advanced economy, fertility may rise as more and more people can afford the luxury. See Myrskylä, Kohler, and Billari [2009].

for the future on a few stressed-out children.[7] He is also bearish on the economic prospects of an aging society. Arnott [2012] has stressed the empirical relation between an aging population (especially one with a high dependency ratio) and diminished productivity growth, leading to poor equity returns. Some of these concerns are legitimate,[8] but I regard the prospect of a stable or even declining human population as wonderful news for the planet, making it much easier to solve environmental and resource problems and enabling greater *per capita* wealth and income to be achieved than would otherwise be possible.[9]

Population stabilization and investing. A world that is getting poorer would be very bad for any kind of risky investment (such as stocks), but one that is getting richer only on a *per capita* basis, while the number of *capita* stays the same or declines, is entirely consistent with strong capital-market returns. This idea can be illustrated using a very simple thought experiment. Suppose each U.S. national were endowed with one share of a comprehensive stock-market index. As the population increases, new stock is issued to maintain the one-person, one-share endowment. The price of the stock is a constant multiple of corporate profits. The price return on this stock (ignoring dividends) is definitionally equal to the change in market capitalization divided by the change in population.

Assume that productivity, an inherently per capita concept, grows by 2% a year; GDP grows by approximately (1+PROD)(1+POP) each year, where PROD and POP are the constant growth rates of productivity and population respectively. Assume further that corporate profits are a constant share of GDP. Since we've already assumed that the stock market is priced at a constant multiple of corporate profits, stock market capitalization also grows at the same rate at GDP. Under such conditions, stock market capitalization, like GDP, grows by (1+PROD)(1+POP) each year.

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[7] With enough depopulation, one runs into real problems. Skills and knowledge are lost. Ridley [2010] wonders aloud whether a modern village of 200 people, blessed with technologies such as double-entry bookkeeping and wireless telephony, could sustain them if the village became isolated. The American Indian depopulation in Columbian times was associated with a devastating loss of cultural capital. However, no one is seriously suggesting that *overall* depopulation on such a scale is about to take place.

[8] But not insoluble! A high dependency ratio can be alleviated by people working longer, not just toward the end of life but toward the beginning (since so much of young people's energy is wasted through inefficient schooling).

[9] The late Julian Simon would almost certainly object to this statement, on the ground that growing populations and wealth-building have been closely allied throughout human history. He might argue that all of the problems we face would be even easier to tackle with more brains and hands at work (and that these factors would overwhelm the cost of having more mouths to feed). The evidence he has accumulated, and the accuracy of his forecasts, are reasons to give his views considerable respect. See Simon [1981, 1996]. I would point out, however, that we have only one sample of the past and that population and wealth both grew tremendously, giving the appearance of a causal relation even if there is none, and making it difficult to find counterexamples without studying collapsed civilizations that have little in common with our own.

Now, what is the impact of population growth on the forecast for this "stock market"?

Faster population growth means faster GDP growth. However, the capitalization of the stock market is continually being split at the POP rate to make new shares, to be issued to new people. Thus, capitalization *per capita* grows at PROD, with no influence from the population growth rate. Since the price return to the investor (return on a per-share basis) is just the change in the stock price — where the stock price has already been defined as capitalization divided by population, or capitalization *per capita* — return is unrelated to population growth. It's unrelated in this highly stylized model, and we suspect strongly that it's unrelated in reality.

The literature connecting population growth, real GDP growth, and capital market returns is somewhat limited, but one brief paper confirms the crucial point that I've just made. William Bernstein [2002] sets forth a very clever method for separating the effects on the stock market of population growth and real per capita GDP growth. He does so by measuring the "leakage" between GDP growth and stock returns — the extent to which stock market performance falls short of GDP growth. This leakage is greatest in countries for which high GDP growth is best explained by rapid population increase (the R^2 is a very high 0.63). Bernstein concludes, "GDP rises are good for stock prices only when they come from increases in individual productivity, as measured by *per capita* GDP; they are bad when caused predominantly by population growth."

It is just as well that rising markets do not require a population boom, because we are not going to get one. What rising markets do require is a rising standard of living (income *per capita*). We now look at global trends in production and income.

RICHER

The Great Fact. One of the more distinctive passages in the history of economic thought comes from the great economic historian Deirdre McCloskey, discussing the possible causes of what she calls the Great Fact of monumental economic growth over the last two centuries:

> What I got with a jolt around age 65 was that economic growth since 1800, the Great Fact of an increase of real income per head by a factor of anything from a factor of 16… to…a factor of 100, had very little to do with routine…adjustment of marginal cost to marginal benefit, [that is, improved] supply-and-demand efficiency, [which is one of the conventional explanations].

Nor, continues McCloskey, did it have to do with private property rights, an explanation favored by Hernando de Soto and many other illustrious scholars:

> China…had secure property for millennia before failing to have an industrial revolution, and… ancient Rome had laws of contract and property, and ancient Greece had banks and wide trade, and Mesopotamia had detailed records of ownership without the slightest signs in the ancient world of a Great Fact.
>
> Holland and England 1600-1800, by contrast…witnessed an obvious and historically unique improvement in the dignity and liberty of the bourgeoisie.

Something of a surprise. McCloskey closes the loop:

> None of the allocative, capital-accumulation explanations of economic growth since Adam Smith have worked scientifically… None of them have the quantitative force and the distinctiveness to the modern world and the West to explain the Great Fact. What works? Creativity. Innovation. Discovery…. And where did discovery come from? It came from the releasing of the West from ancient constraints on the dignity and liberty of the bourgeoisie, producing an intellectual and engineering explosion of ideas. As…Ridley [2010] has recently described it, ideas started breeding, and having baby ideas, who bred further.

So ideas having babies, not capital accumulation, are responsible for the most astounding increase in wealth and well-being in the history of humanity? Likely story. McCloskey is, of course, correct, and any analysis of the Great Fact should proceed from this starting point: the decision to save some of what one produces and invest it for the future isn't nearly enough to explain economic growth that has been self-sustaining for more than two centuries; only an explosion in creativity and invention is.

(I began this section with a meditation on the history of economic thought because it is a little dumb to begin it with, "Over the last 200 years, the world has gotten tremendously richer." Everybody knows it. Yet it is still possible to know this and, simultaneously, to hold the view that conditions are getting persistently worse, and to long for days gone by.[10])

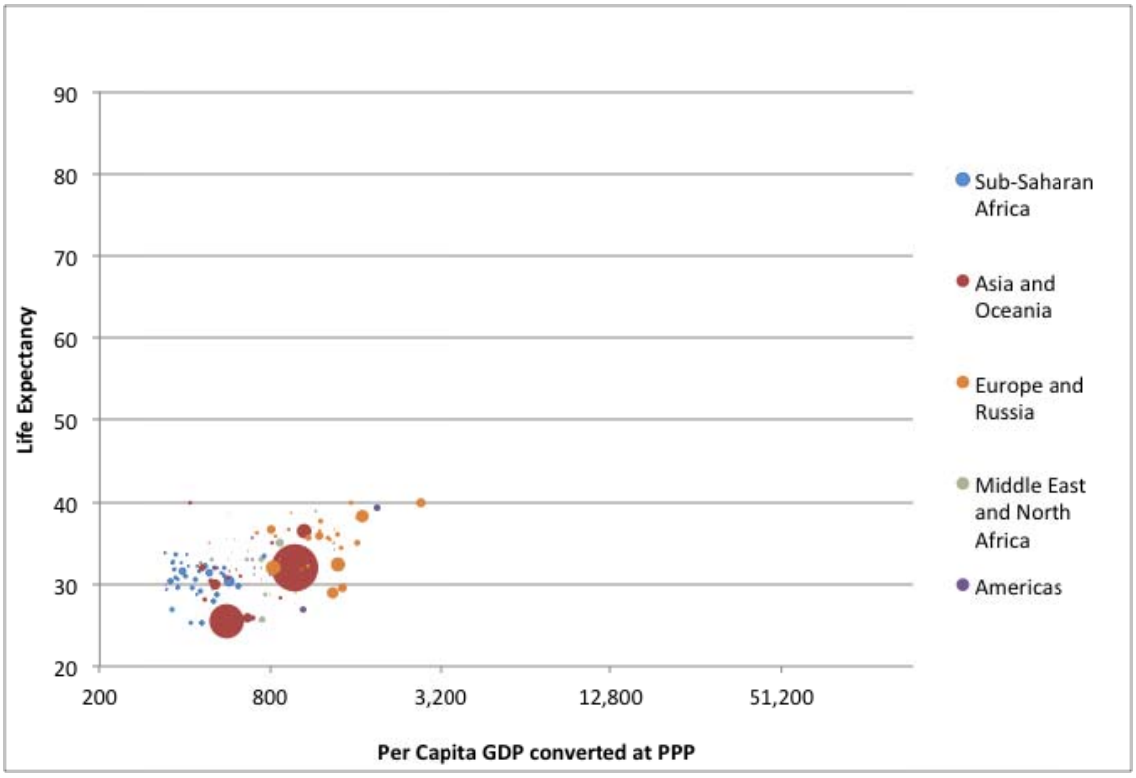
[10] For a much fuller discussion of nostalgia as a persistent cognitive error, see Ridley [2010].

The Great Fact can be summed up in one data point: The PPP-adjusted per capita GDP for the *world* in 2010, $11,200, is equal to the per capita GDP (in the same units) for the United States in 1929. In 1929 the U.S. had the highest standard of living in the world and was, by any reasonable accounting, very much a developed country.[11]

Since we tend to take the world's past economic development for granted, let's *briefly* review the history. Most pictures are worth a thousand words, but the Swedish physician and statistician Hans Rosling's ingenious data graphs are worth a multiple of that, so let's look at the graphs, which are more or less self-explanatory.

FIGURE 4

THE WORLD IN 1800: INCOME, LIFE EXPECTANCY, AND POPULATION

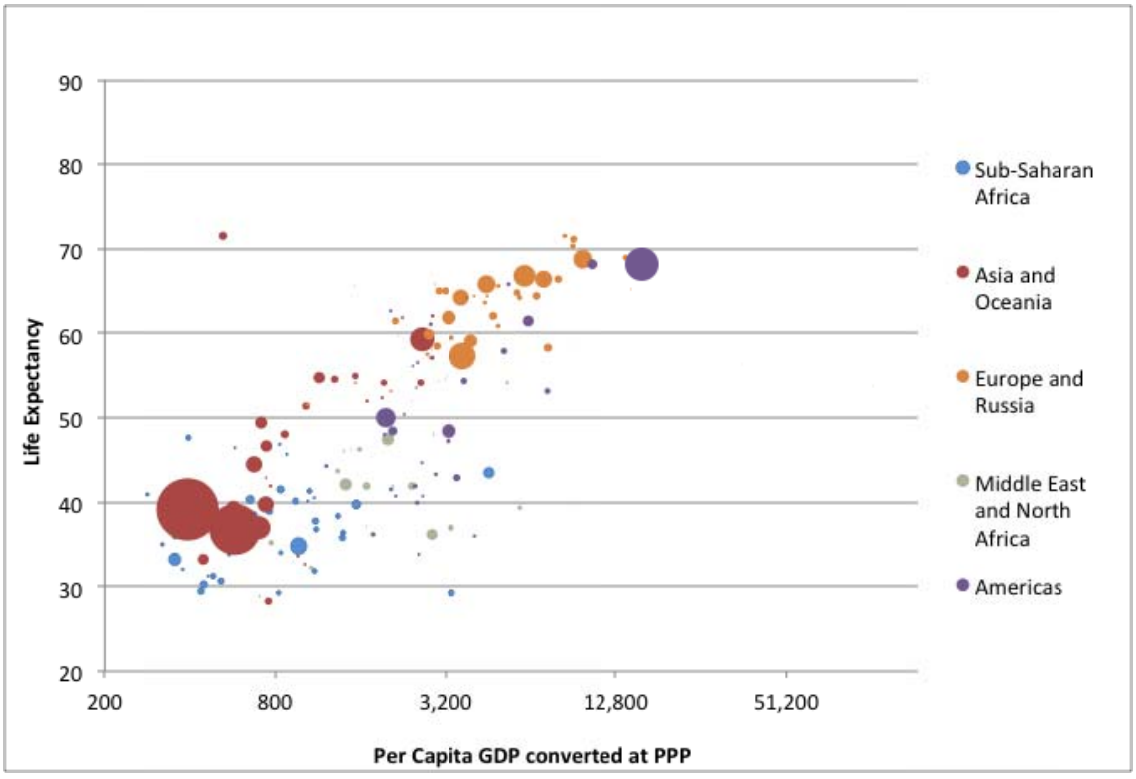


[11] The number shown for 2010 is from the *CIA World Factbook* [2010]. The 1929 number reflects Maddison's [2009] estimate of $6,899 in 1990 Geary-Khamis dollars, which inflates to $11,942 in 2011 dollars (according to the U.S. Bureau of Labor Statistics inflation calculator at http://data.bls.gov/cgi-bin/cpicalc.pl, which uses CPI-U inflation rates). Note that U.S. *per capita* GDP fell sharply after 1929, then recovered, surpassing the 1929 high by 1940 (and then never again falling below that level). World average per capita GDP is not available for 1929, but was $3,389 (2011 dollars) in 1940 (once again drawing on Maddison [2009] and inflating to the present).

I have included a Rosling graph for the intermediate year of 1950 because it corresponds roughly with "peak inequality." While the developed world was well on its way to modern levels of health and wealth, parts of the less developed world had not moved much from early nineteenth-century levels, and China was poorer than at any time since 1500. Ironically, some Americans who claim to be exercised about inequality consider the 1950s to be the good old days.[12]

FIGURE 5

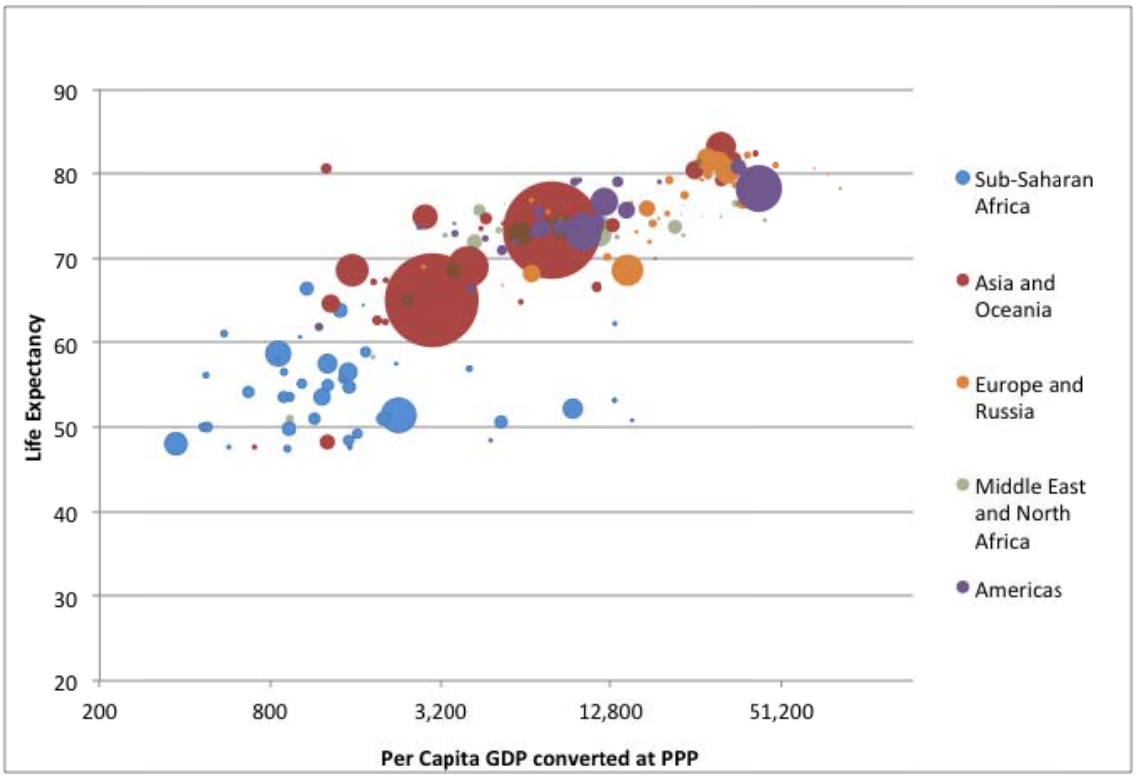
THE WORLD IN 1950: INCOME, LIFE EXPECTANCY, AND POPULATION



[12] The 1950s are the good old days if you only care about people in the United States, if you ignore racial minorities, and if equality, not absolute prosperity, is the relevant welfare measure.

FIGURE 6

THE WORLD IN 2012: INCOME, LIFE EXPECTANCY, AND POPULATION



Economic development since 1800 can, thus, be broken up into two subperiods: a Great Decompression of 1800 to roughly 1950, during which the developed world achieved essentially a modern standard of living, leaving the rest of the world far behind; and a Great Convergence of roughly 1950 to the present, when the rest of the world started to catch up. The developed world continued to get richer, *but not in relative terms* (a source of great worry to some people!)

Forecasts of future wealth. The Great Fact is, of course, only an observation about the past and is not necessarily a forecast of the future. But developed-country growth rates have been remarkably stable over two centuries (as documented by Arnott [2011]), and developing-country growth rates have only accelerated.[13] There is almost no hint in the data of a deceleration.[14] Moreover, the forces that propelled economic

[13] In a personal communication from Robert D. Arnott, graphed as Exhibit 6 in Grinold, Kroner, and Siegel [2011], Arnott documents a 1.8% *per capita* real GDP growth rate in the U.S. from 1789 to 2008. The rate is remarkably constant across subperiods.

[14] Controversially, and I think wrongly, Tyler Cowen [2011] finds a hint of deceleration in the U.S., but says that "America…[having] got[ten] sick…will (eventually) feel better." My critique of Cowen's analysis is that the transition that he describes, from "eating low-hanging fruit" to making difficult and costly improvements, just barely shows up in the data: overall growth in the 1980s and 1990s was almost as rapid as in the 1950s and 1960s; there is stagnation in median but not mean incomes.

growth between 1800 and the present have not changed. Most important, creativity and invention have not stopped, but seem to be accelerating further.

The doomsayers tend to ascribe past growth to the exploitation of cheap energy, cheap labor, and cheap land. While these factors could produce some economic growth, they were at work in the centuries before 1800 and the growth did not materialize. Moreover, energy was never more expensive, at least in terms of human effort (isn't that what counts?), than when all of it had to be produced by human muscle power – typically slave power. Successively cheaper energy sources include animal muscle power, water and wind power, wood, coal, oil (at first extracted from the blubber of whales!), nuclear energy, and sources yet to be discovered (or already discovered but not yet economical to exploit).

Each time that energy production transitioned from one source to another, the transition occurred because the old source had gotten expensive (reflecting increasing scarcity), making the new source economical where it had not been earlier. This process will continue to occur. And it will occur not just for energy, but for every resource that appears to constrain economic progress.

A compound rate of increase in consumption – of anything – in the face of fixed supply is, of course, unsustainable. It is tempting to see this fact as an impenetrable barrier, but economics asks: even if the supply of the resource is fixed, is the supply of the *service provided by the resource* really fixed? If not, if substitutes can and will be found at some price, then economic progress is not constrained, although the higher cost of the service needs to be factored into growth forecasts.

I cannot forecast the future quantitatively, but there are those who try. In 2005-2006, Goldman Sachs (Wilson and Stupnytska [2007]) prepared forecasts of *per capita* GDP by country, in then-current dollars. The forecasts are in Table 2, along with current (2010) GDP for comparison.[15] Countries are listed in order of their anticipated GDP *per capita* in 2050.

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[15] The current incomes are PPP-adjusted while the forecasts are not. While this seems a little unfair, I think it advisable to use the best data available in each time period. Clearly, for comparing standards of living, PPP-adjusted data are much better than unadjusted data, so I use them for the current time frame. The Goldman analysis seems to assume that purchasing-power differences among currencies will disappear between now and 2050.

"Nominal" GDP *per capita,* converted at the market exchange rate, measures the amount of goods and services that a year's *per capita* income in a given country would buy if that income were consumed in the United States (at U.S. prices). PPP GDP per capita, in contrast, measures the amount of goods and services that a year's *per capita* income in a given country would buy if that income were consumed in the country in which it was earned (for example, a U.S. dollar goes farther in China than it does in the United States, so China's PPP GDP *per capita* is higher than its "nominal" or market-rate GDP *per capita*). As noted in De Rosa [2009], "PPP exchange rates are preferred for comparing living standards among countries" (p. 2).

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TABLE 2

CURRENT (2010) AND FORECAST (2050) GDP PER CAPITA, BY COUNTRY

	2010 PPP-adjusted GDP per capita in U.S. dollars*	2050 Projected GDP per capita in U.S. dollars**		2010 PPP-adjusted GDP per capita in U.S. dollars*	2050 Projected GDP per capita in U.S. dollars**
United States	47,200	91,683	China	7,600	49,650
South Korea	30,000	90,294	Turkey	12,300	45,595
United Kingdom	34,600	79,234	Vietnam	3,100	33,472
Russia	15,900	78,435	Iran	10,600	32,676
Canada	39,400	76,002	Indonesia	4,200	22,395
France	33,100	75,253	India	3,500	20,836
Germany	35,700	68,253	Egypt	6,200	20,500
Japan	34,000	66,846	Philippines	3,500	20,388
Mexico	13,900	63,149	Nigeria	2,500	13,014
Italy	30,500	58,545	Pakistan	2,500	7,066
Brazil	10,800	49,759	Bangladesh	1,700	5,235

* Current (2010) dollars.

** Projections as of 2005-2006, in 2006 U.S. dollars.

The forecasts are a little high because they were made before the Great Recession. This only means, however, that if Goldman Sachs got the overall pattern of growth rates right, the numbers will be achieved in 2056 instead of 2050 for developed countries, and in 2051 or 2052 for emerging markets. Of course there is a forecast error term, so that the realizations will be different from the forecasts, but it would be very surprising if the direction and general magnitude of the forecasts were wrong.

Mexicans sporting an average income 30% higher than the current U.S. average, and Indians with an average income equal to that of the United States in the 1960s, will be citizens of a world that is profoundly different – *and profoundly better* – than any past or present reality. There is every reason to expect this to happen; and it will happen more or less on schedule, within our children's or, at most, our grandchildren's lifetimes.

But all these rich people will consume a lot.[16] What will this consumption do to the environment, to the planet?

[16] My use of the word "rich" is an economist's use, and may not comport exactly with the popular conception. The rich U.S. has many poor people, and a somewhat richer Mexico in the 2050s will too; needless to say, so will India in the 2050s with one-third the *per capita* income. But billions of people around the world will have been lifted out of poverty, and hundreds of millions more will have been lifted from middle-income status to what an American, European, or Japanese reader would regard as true affluence.

GREENER

It is almost an article of faith among educated readers that the world's past economic development has seriously degraded the natural environment and that future economic development on the scale I'm describing will destroy the planet. Let's examine this proposition.

The U.S. national parks are among the world's most beautiful, healthful, and unspoiled places. How did they come into being?

Why is the northeastern United States more densely forested than it was in 1850, 1900, or 1950?

The country of Switzerland resembles one big national park.[17] The air and water are splendidly clean, and the natural beauty of the place is preserved. With a relatively dense population, about 485 people per square mile, denser than China or Nigeria, how did this happen?

These paragons of environmental conservation have one common factor: they have been rich for a long time. The U.S. national park system was founded in 1872, and was developed into its modern form by President Theodore Roosevelt at the turn of the last century. In 1872 the U.S. was not yet the world's richest country, but it was in the top half-dozen: basic needs had been met to the extent that, in a democracy, it was not inconceivable to divert a portion of tax revenues to environmental protection.[18] By Roosevelt's day the U.S. could afford to have conservation become a major government program. Switzerland and other countries at the top of the income scale tell a similar tale. (I'll get to the northeastern U.S. forests later.) Effective environmental protection cannot be achieved through private action alone; much of it requires the kind of mass cooperation that can only be enforced by government. But, in a free society, taxpayers must consent to their taxes being used in this way, or the environmental protection will not take place.

Why this emphasis on government? Private agents always externalize, or get other people to pay part of their costs, as best they can (and competition forces them to do so even if they'd rather not). Many, but not all, environmental effects are externalities — they consist of harm to the "commons" (property held in common by the people). Examples of such externalities are pollution (air, water, noise, etc.) and overgrazing or overfishing. Such harm is suffered by individuals who do not benefit from the transaction causing the harm, and can only be alleviated through government regulation or direct government action.

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[17] Which is, amazingly, smaller than the largest U.S. national park (Wrangell-St. Elias in Alaska — 20,625 square miles, compared with 15,940 for Switzerland).

[18] In non-democracies, kings and other despots have often preserved natural resources for their own use (often as parks), whether or not the people's basic survival needs were being met.

Free-market environmentalists have noted that if there were no commons – if private property rights could be established in everything, including air, water, forests, fisheries, and so forth – then the environment could be protected by the owners of these goods acting in their own interest. However, it is unrealistic to think that private property rights can be established that broadly, although there is some progress in that direction (see the discussion below of Iceland's fisheries).

The environmental Kuznets curve. Recalling my earlier observation that rich countries tend to be green, one might hypothesize that a society is as green as it can afford to be. But this principle does not hold up at all income levels. In the early stages of a country's economic development, the environment becomes degraded pretty quickly. Why? As an economy begins its rise out of poverty, progress must be made on the cheap (that is what it means to be poor). Low incomes are also often associated with high population growth rates.

Thus we have the following time progression: land unsettled by humans is pristine. Subsistence living, with its very high discount rates, is the most environmentally destructive lifestyle known to man, but the population may be too small for the damage to be immediately obvious. Rapid industrialization causes profound environmental problems. After reaching a tipping point where environmental protection becomes a desirable and affordable expense, however, a society becomes greener. Fewer, richer, greener.

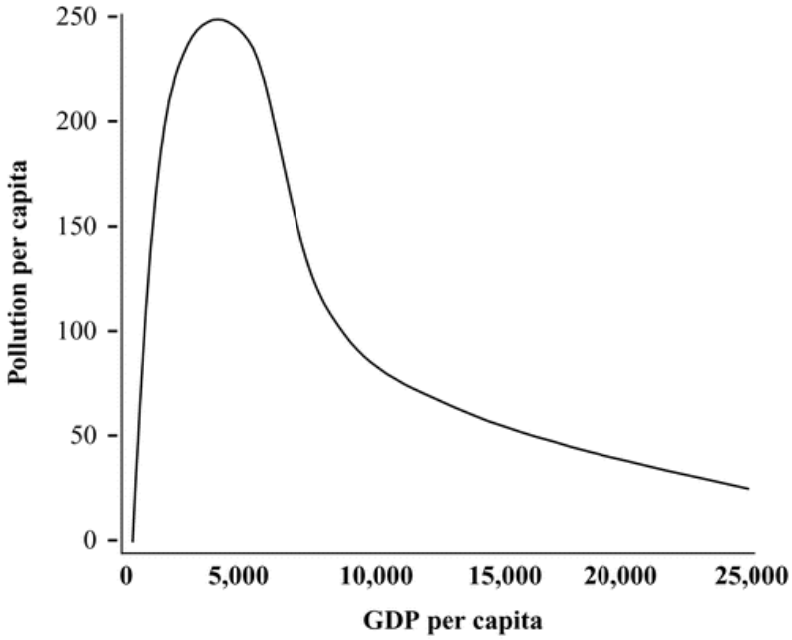
In 1955 the economist Simon Kuznets observed an inverse U-shaped relation between economic development and income inequality. As an economy first develops, incomes became more unequal as a few successful people take advantage of newfound opportunity. At a later stage of development, incomes become more *equal* as capital becomes abundant enough to make even unskilled labor more productive. We saw a version of this phenomenon earlier when making comparisons across (not within) countries, noting that peak inequality had occurred around 1950.

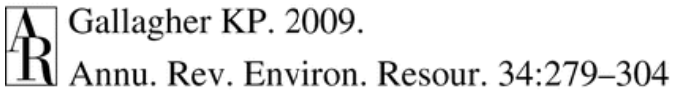
Inspired by Kuznets, researchers beginning with Grossman and Krueger [e.g. 1995] have fitted the pattern of worse, then better, environmental conditions as an economy grows to the curve that Kuznets developed for a different purpose. These researchers call the resulting relation the "environmental Kuznets curve" (EKC), the general pattern of which is shown in Figure 7.[19] The science reporter for the New York Times, John Tierney [2009], summarized EKC theory by saying, "The richer everyone gets, the greener the planet will be in the long run." Tierney's work was welcomed warmly in some circles and greeted with derision and outrage in others, but the EKC has become one of the most widely discussed and debated topics in environmental policy, spawning over 100 scholarly papers by 2004.

[19] An earlier, unpublished 1991 paper by Grossman and Krueger contains the original reference to an EKC. An excellent primer on the EKC is in Yandle, Vijayaraghavan, and Bhattarai [2002].

FIGURE 7

HYPOTHETICAL ENVIRONMENTAL KUZNETS CURVE FOR A GENERIC POLLUTANT



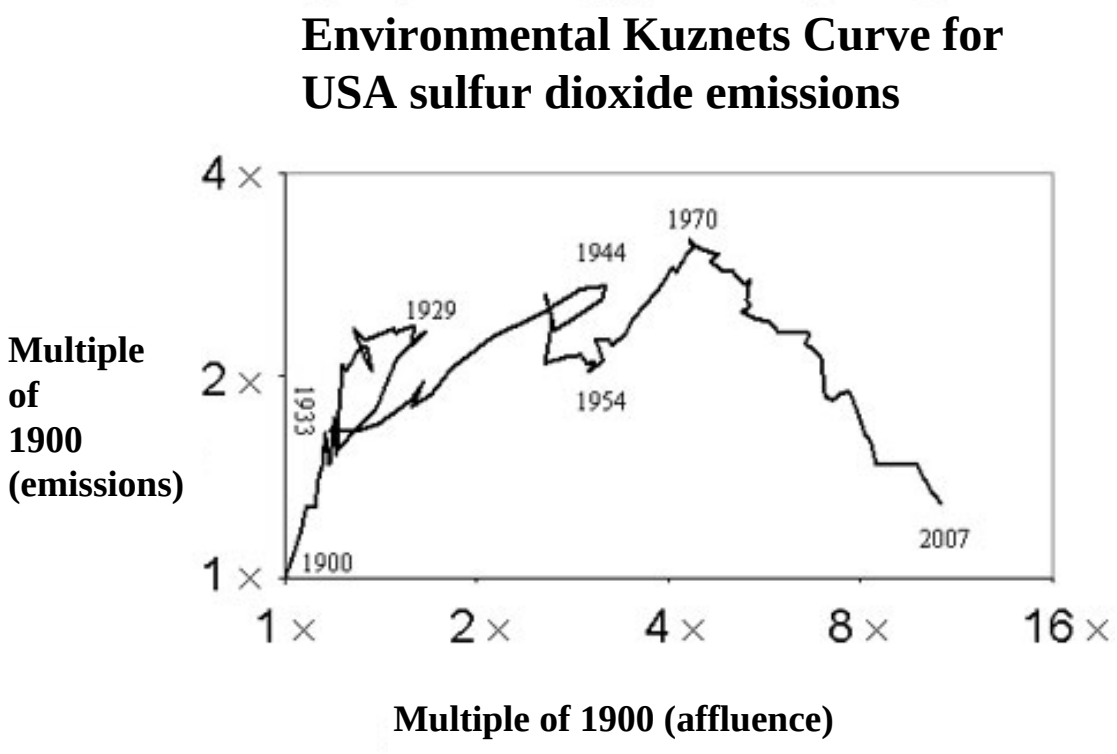


Source: Gallagher [2009].

Research on specific environmental variables tends to confirm the EKC, but unevenly: the theory "works" better for some resources than for others. Industrial pollutants follow the hypothetical EKC very closely: here's the empirically estimated curve for sulfur dioxide.

FIGURE 8

ENVIRONMENTAL KUZNETS CURVE FOR U.S. SULFUR DIOXIDE EMISSIONS



Source: Ausubel and Waggoner [2009], cited in Tierney [2009b]. Strip out double title.

Forests. The EKC also works well for forestation. While some developing countries are still cutting down forests to obtain arable land, the United States has experienced dramatic reforestation, especially in the Northeast. This reforestation began when the opening of the U.S. Midwest in the early to middle 19th century made previously valuable Northeastern farmland marginal, and has continued to the present day. The market environmentalist Jonathan Adler, writing in 1993, noted,

> In the past 40 years, timberland east of the Mississippi has expanded by 3.8 million acres, in addition to the nearly three million acres in the eastern United States that have been declared wilderness in the past two decades. By 1980, New England contained more forested acres than in the mid-19th century; Vermont is now twice as forested as then. Fifty-nine percent of the northeastern United States is covered by forest. (Adler [1993], p. 84)

This is not simply a matter of land returning to its natural state. Forests are a positive good, and people are willing to pay to live in or near one, or to visit one. Ellen Stroud, a Bryn Mawr College environmentalist and urbanologist, has written, "It is no coincidence that the most heavily urbanized part of the country has experienced the most dramatic return of woodlands… The desires and physical needs of city people encouraged and required the return of the forest" [Stroud 2012].

The EKC seems to break down, however, for biodiversity and for goods that are usually held in common, such as fisheries. Biodiversity cannot obey a conventional EKC because extinction is a one-way street. A species that is made extinct cannot be brought back – so biodiversity, as measured, only goes down. (New species are evolving all the time, but we are unable to observe that process directly.) The best we can hope for is to reduce the rate of species extinction to near zero.

Fishing. Fisheries and other resources held in common also usually fail to conform to the EKC model. While a fishing ground is self-renewing in the long run, the incentive for overfishing is not typically balanced by any countervailing force other than diminishing returns to effort, with the result that fisheries typically degrade over time. A system of enforceable property rights would probably eliminate this problem, but it is hard to establish property rights in fish (they swim away). But it's not impossible. Michael Lewis [2011] describes an ingenious system, used in Iceland, which has had the effect of conserving fisheries there:

> [T]hey privatized the fish. Each fisherman was assigned a quota, based roughly on his historical catches… [entitling him] to, say, 1 percent of the total catch allowed to be pulled from Iceland's waters that season. Before each season… scientists… would determine the total number of cod or haddock that could be caught without damaging the fish population; from year to year, the numbers of fish you could catch changed. But your percentage of the annual haul was fixed…in perpetuity [and], even better, if you didn't want to fish you could sell your quota to someone who did. The quotas thus drifted into the hands of…the best fishermen, who could extract the fish from the sea with maximum efficiency.

Creative thinking along these lines will be required if the potential environmental benefits of greater wealth are to be realized.

Climate change. Although some thoughtful observers question it, we appear to be in a global warming phase, at least similar in scale to the Roman and Medieval warmings. (The Medieval one reached an astonishingly high peak in the North Atlantic, making southern Greenland arable and enabling Newfoundland to be called Vinland or Vineland.) Any large-scale climate change, warming or cooling, is problematic because human settlement and agriculture are already optimized around the current climate. It is less clear, although certainly possible, that the modern warming is related to increased atmospheric carbon dioxide concentrations, caused by human activity.

If the most widely-accepted warming projections are correct, what happens to my forecasts? According to the Natural Resources Defense Council, a global warming "hawk," the all-in cost of global warming is projected to be 3.6% of GDP on an ongoing basis.[20] At the 1.8% historical per capita GDP growth rate, this amounts to GDP projections being realized two years later than otherwise. At the 1% growth rate that is a likelier outcome for the most highly developed economies, GDP projections will be realized three and a half years later than otherwise. This is unfortunate but far from catastrophic, and delays GDP attainment by about as much as the 2007-2009 recession did.

Running out of and into oil. Energy is the "master resource," said Julian Simon, because it "enables us to convert one material to another," so that we can create any other resource that we need. We would do well to be concerned about its continued supply and cost. In fact, some observers are more concerned about the limits to economic growth caused by resource scarcity than they are about environmental degradation. If the growth cannot occur because we do not have the raw materials for it, why worry about the consequences of growth that won't happen? We should worry about poverty and resource exhaustion instead.

In a fascinating Q Group presentation, David Greene of Oak Ridge National Laboratory [2004] projects the supply and demand for oil and other energy resources through 2050. The title of his presentation, "Running Out Of and Into Oil," reflects the fact that we have been running into oil — discovering it — at about the speed we are using it, or a little faster. As a result, if, as of a given date, we have 30 years' "reserves," 30 years later we may have 40 years' reserves. It is all very counterintuitive. The trick is that "reserves" indicate the amount of oil that can be extracted from known sources profitably at the current price. Reserves based on known sources are larger at higher prices; and more effort is expended in discovering

[20] I do not know how this estimate was arrived at, but a comprehensive estimate of the economic impact of global climate change would include migration away from overheated or desertified areas, resettlement of near-sea-level populations, conversion of marginal land (marginal because it is now too cold) to agriculture, and other adjustments.

new sources at high prices. However, the amount of oil is not infinite, and this fact needs to be taken into account in any analysis.

One of the more optimistic scenarios studied by Greene is a demand-driven (not supply-driven) peak in oil production around 2040. In a demand-driven peak, both the price mechanism and conservation are at work. As oil becomes more scarce and costly to extract, the price rises to the point where non-oil sources of energy are more attractive; at the same time, demand eases due to conservation or energy efficiency (relative to the massive growth in consumption that would otherwise occur).

Other scenarios that Greene studied are less favorable, and in 2009 he commented that the current rate of oil consumption, relative to the total amount of oil that will ever be extracted, is "alarming" (Greene [2009], slide 7). Overall forecasts of economic growth should take into consideration both high oil prices – which Greene did not foresee in 2004, despite his detailed analysis – and the potential difficulty in developing other sources of energy.

The same logic applies to other resources. Nothing is in infinite supply, but new discoveries and ways of using existing resources more efficiently can cause the supply curves for most or all resources to move profoundly over time.

Investment Advice

I wish I knew how to turn these futuristic thoughts into highly specific investment recommendations. If I did, I would start a hedge fund and make the world greener with my riches.

I can, however, make some general observations and suggestions. The immense amount of consumption implied in these forecasts — both at the end-user level and at various intermediate production stages — means that the following will be in great demand:

- *Food* and its "ingredients" — farmland, fertilizer, agritechnology. Even a stable or declining population will want to eat higher-quality food with more protein.
- *Water* and delivery systems for clean water
- *Energy,* both traditional and alternative – we're going to need it all
- *Minerals and other basic materials*
- *Forestry*
- *Infrastructure,* desperately needed, with demand expressed through public and private sectors
- *Environmental quality,* a "luxury" the world can finally afford — and will

The investment media for most of these are straightforward: equities, commodities (but see below), private securities. Investing in environmental quality is a little more difficult, and mostly involves selecting companies (public or private equities) that will benefit from spending on the environment.

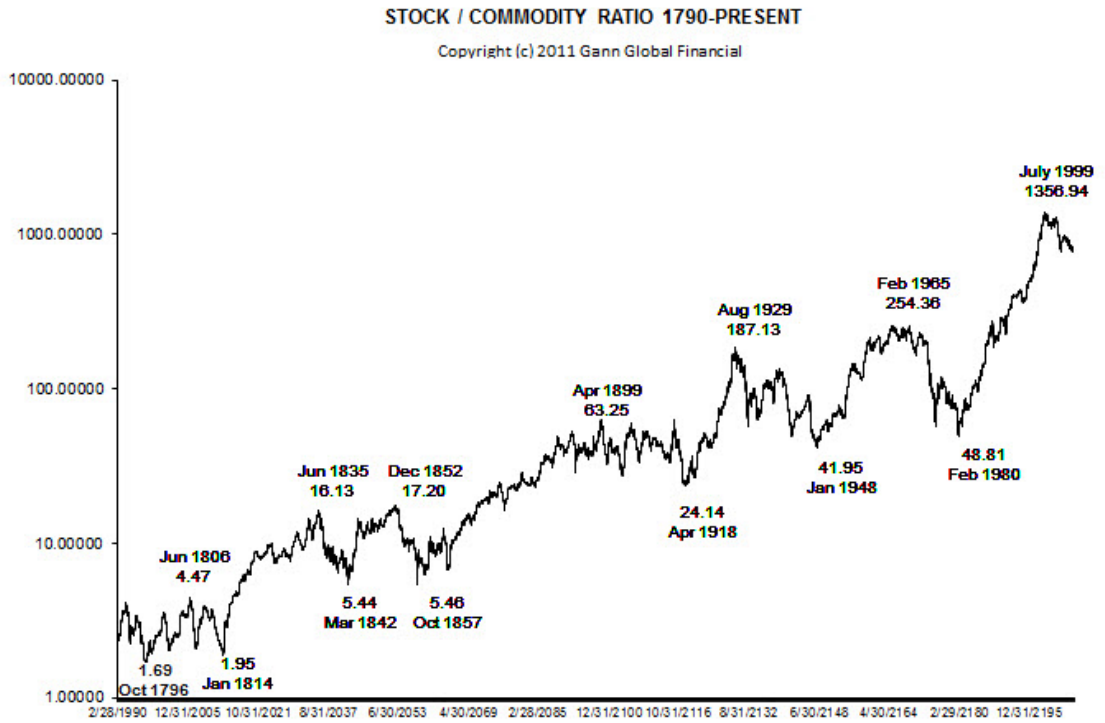
Asset allocation. The expectation of massive future growth favors equities over bonds: if we're really going to be much richer, fixed-claim holders will get their fixed claims and variable-claim holders will get much more. Table 2 suggests that the increased riches will be strongly tilted in favor of emerging and frontier markets; by all means hold them, but also buy stocks of developed-market companies that make a substantial share of their profits in these markets. Alternative investments are probably the best medium for making focused commitments to asset classes, such as mining, farmland, and forestry, which are hard to obtain in the stock market. Finally, one should not overlook debt instruments: in any given situation, they may offer a better risk-return tradeoff than equity in the same asset or deal, or the debt instrument may be the only security available.

Commodities. Many investors, hearing the story I've told, would respond by increasing their allocation to commodities. While this is a reasonable reaction, commodities are already very high-priced and the going-in price for any investment is a primary determinant of subsequent return. Figure 9 shows the relative return of equities and commodities (a cumulative index of the stock market divided by a cumulative commodity index) over 1790 to the present.[21]

[21] Stock market data before 1871 are of unknown quality.

FIGURE 9

RELATIVE PRICE OF STOCKS AND COMMODITIES, CUMULATIVE INDEX 1790 TO THE PRESENT



Source: Gann Global Financial. Accessed at http://www.gannglobal.com/stock-commodity-prices-decouple/ on February 29, 2012. The *x* (time) axis is displaced by 200 years, so that "1990" (at the lower left corner) represents 1790, and so forth.

The stock/commodity ratio has moved in long waves; that is, the series has a high serial correlation. The current move in favor of commodities and against stocks is becoming significant by historical standards; commodities have gotten expensive and stocks are (somewhat) cheap. The graph also indicates that stocks have outperformed commodities on average over time, although with a great deal of variability.

In general, buying stock in the companies that own or produce the commodities is a better idea than investing directly in commodity futures. One reason is that commodity futures returns are strongly influenced by backwardation and contango, which are fancy words for the term structure of futures prices. (You cannot buy "spot," or physical, commodities, unless you have a place to store them.) The term structure effects can overwhelm the underlying commodity return. A more fundamental reason to buy the companies rather than the commodities is that the price of the company's stock includes a real option, the option to produce less (or none) of the commodity when it is not profitable but to keep it in reserve, and to ramp up production when it is profitable. The presence of this option reduces risk. However, because stocks and commodities have been negatively correlated in the past, although not recently, this

negative correlation may reappear and investors may wish to make some direct commodity futures investments as a hedge.

Human capital. Finally, investors should seek out ways to invest in human capital (the present value of future labor income). The riches of the future will accrue primarily to labor in the form of rising standards of living, rather than to capital. Portfolio investment in human capital is difficult almost by definition: you can't buy shares of individual people. However, there may be equities, debt securities, currencies, or commodities that correlate highly with human capital. Identifying these involves security analysis that is well beyond the scope of this essay.

One approach might be to invest in intellectual property, either directly (as some hedge funds do) or by buying stocks of companies that own or produce a lot of intellectual property. Hirshleifer, Hsu, and Li [2011] have noted that some companies are efficient at turning research and development funds into intellectual property, while others seem to spend a lot on R & D but get little for it. The authors find a strong relation between this "innovative efficiency" and subsequent stock returns. Thus, investors pursuing a human-capital theme might consider buying stocks of innovatively efficient companies.

All right, I'm done. I'm tired of hearing so many people whine about the miserable future, and scare their children. The future will be much like the present, but better in many ways and worse in a few. At any rate, it hasn't happened yet so you can do something about it. Wealth accumulation may be inevitable but it isn't easy. Get to work.

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